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Las Vegas Valley Water Budget: Relationship of Distribution, Consumptive Use, and Recharge to Shallow Ground Water

Nevada Univ., Las Vegas

Prepared for

Robert S. Kerr Environmental Research Lab., Ada, OK

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Las Vegas Valley Water Budget

Relationship of Distribution, Consumptive Use, and Recharge to Shallow Ground Water

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16. ABSTRACT

Estimates of quantity and geographic distribution of recharge to the shallow ground-water zone from water use return flows in Las Vegas Valley were made for the years 1973, 1965, 1958, 1950, and 1943 as part of a broader study on the impact of water and land use on ground-water quality. Considered components of water use in Las Vegas Valley include the following: supply from surface and ground water; agriculture using potable water; agriculture using sewage effluent; residential lawn watering; lawn watering of parks, schools, cemetaries, hotels, motels; golf courses using potable water; golf courses using sewage effluent water; septic tank recharge; evaporative coolers; system losses; industrial use; power plant cooling; swimming pool use; consumptive use by phreatophytes; in-valley recharge from precipitation, and "unaccounted for water". Consumptive use of plants was calculated through use of the Blaney-Criddle method as 3.47 feet per year and recharge was assumed to be the difference between applied water and calculated consumptive use. Data developed during this study indicates consumptive use as determined by this method could be low by 1.5 to 2 feet per year, and thus the following estimates of recharge to the ground-water system are considered maximum, in acre feet: 1973-39,000; 1965-27,600; 1958-26,650; 1950-13,000; and 1943-21,000.

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LAS VEGAS VALLEY WATER BUDGET: RELATIONSHIP OF DISTRIBUTION, CONSUMPTIVE USE, AND RECHARGE TO SHALLOW GROUND WATER

by

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FOREWORD

Since the vast influx of population began pouring into the Las Vegas Valley in the 1940's the hydrologic regime of the Valley has undergone significant change. The pristine environment of the Valley was desert with desert vegetation and no perennial flow out of the Valley. With the increase in population came the proliferation of lawns, shrubs, and trees throughout the Valley. This domestic irrigation of vegetation together with wastewater return flows has created a perennial stream leaving the Valley through Las Vegas Wash. This study was implemented to determine what is happening in the shallow ground-water zone (0 to 300') within the Valley, its flow, and the main sources of contamination. Results of this study have been divided into three volumes, the first volume entitled, "Land and Water Use Effects on Ground-Water Quality in Las Vegas Valley," deals with the problem of how ground-water quality is affected by land and water use throughout the Valley. This publication, volume two, gives a detailed picture of the input and outflow of the water being used in Las Vegas Valley. The third volume, "Simulation Modeling of the Shallow Ground-Water System in Las Vegas Valley," discusses the problems and water level fluctuations in the shallow ground-water system.

These three volumes represent an assessment of the shallow ground-water system in Las Vegas Valley and should be of use to anyone dealing with that aspect of the hydrologic regime in Las Vegas Valley.

Gilbert F. Cochran
Acting Executive Director

ABSTRACT

Estimates of quantity and geographic distribution of recharge to the shallow ground-water zone from water use return flows in Las Vegas Valley were made for the years 1973, 1965, 1958, 1950, and 1943 as part of a broader study on the impact of water and land use on ground-water quality. Considered components of water use in Las Vegas Valley include the following: supply from surface and ground water; agriculture using potable water; agriculture using sewage effluent; residential lawn watering; lawn watering of parks, schools, cemetaries, hotels, motels; golf courses using potable water; golf courses using sewage effluent water; septic tank recharge; evaporative coolers; system losses; industrial use; power plant cooling; swimming pool use; consumptive use by phreatophytes; in-valley recharge from precipitation, and "unaccounted for water". Consumptive use of plants was calculated through use of the Blaney-Criddle method as 3.47 feet per year and recharge was assumed to be the difference between applied water and calculated consumptive use. Data developed during this study indicates consumptive use as determined by this method could be low by 1.5 to 2 feet per year, and thus the following estimates of recharge to the ground-water system are considered maximum, in acre feet: 1973-39,000; 1965-27,600; 1958-26,650; 1950-13,000; and 1943-21,000.

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LIST OF ABBREVIATIONS

A.F.B.	--	Air Force Base
BMI	--	Basic Management Incorporated
CCSDTP	--	Clark County Sanitation District Treatment Plant
CLVSTP	--	City of Las Vegas Sewage Treatment Plant
DWR	--	Division of Water Resources, State of Nevada
ET	--	Evapotranspiration
FHA	--	Federal Housing Administration
ft/yr	--	feet per year
gal/day	--	gallons per day
gpd	--	gallons per day
Hend.	--	Henderson
LVVWD	--	Las Vegas Valley Water District
mgd	--	million gallons per day
NASA	--	National Aeronautics and Space Agency
VA	--	Veterans Administration
WRC	--	Water Resources Center of Desert Research Institute

METRIC CONVERSION

To Convert	Multiply By	To Obtain
acres	4.047×10^{-1}	hectares
acres	4.047×10^{3}	square meters
acre feet	1.233×10^{3}	cubic meters
inches	2.540	centimeters
miles	1.609	kilometers
feet	3.048×10^{-1}	meters
gallons	3.785×10^{-3}	cubic meters

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INTRODUCTION

The water budget studies presented herein are a part of a broader Environmental Protection Agency supported research effort directed at evaluation of the shallow ground-water system of Las Vegas Valley initiated in 1970 and essentially completed in 1974.

In order to study the quantitative and qualitative effects of urban water use on recharge to the shallow ground-water system in Las Vegas Valley, it was desirable to develop water use budgets describing water supply and water use components. Budget components were considered on a geographic basis to determine where return flow to the ground-water system should be occurring, and in what quantity. In terms of water quality, budget data for the various types of water uses and calculated estimates of return flow to the shallow ground-water system lend perspective to sources of constituents, magnitude, timing, and distribution (Kaufmann, 1976). In terms of ground-water modeling, these budget data provide the means to estimate recharge and discharge values for node points (Westphal, 1977).

Applied use data were developed and distributed in the Las Vegas Valley in two ways: first, Valley-wide to include most of the urban, commercial and industrial area, and second, to include only the area of digital models developed as part of the overall study of the shallow ground-water system of Las Vegas Valley (Westphal, 1977). Valley-wide budgets and recharge - discharge data for the model area were calculated for base years 1943, 1950, 1958, 1965, and 1973. Aerial photography was available for these years and facilitated more accurate estimations of irrigation distribution.

CONCLUSIONS

1. Careful investigation of supply and use of water in Las Vegas Valley indicates that considerable return flow to the shallow ground-water system occurs. Since at least 1943 on a Valley-wide basis, recharge to the shallow ground-water system appears to be in significant excess of the discharge from the shallow system. This implies net increase in storage in the shallow system.

2. Domestic residences use about twice the amount of water necessary to adequately irrigate lawns in Las Vegas. Application rates are 100 percent higher on residential lawns than where professional gardening is done.

3. There is limited opportunity for significant potable water savings outside of residential uses.

4. The resort industry does not appear to be a particularly large user of water (7 percent) when compared to the role it plays in the community's economy. However, much of the residential water use is indirectly related to the industry, and the thirteen golf courses in the Valley reflect the orientation of the economy to resort activities.

5. Swimming pools, contrary to popular belief, are not a significant water user (0.4 percent). Consumptive use is approximately the same as the lawn they commonly replace.

6. Table 1 shows estimated usage of water in Las Vegas Valley in 1973.

7. Aerial photography, particularly infrared, can be used to accurately determine amounts and geographical location of recharge to the shallow ground-water system in an urban area.

8. Actual in-house per capita water use is estimated at 107 gallons per day (gal/day), or about average for the nation.

9. The recharge values adopted, i.e., those of the Blaney-Criddle method, are believed to yield upper limits of recharge from irrigation. Recharge to the shallow system was calculated as the difference between applied use and consumptive use. Because experts disagree on consumptive use methods, recharge values calculated by the Blaney-Criddle method, Olivier method and consumptive use estimates of local agricultural experts are listed in Table 2 to show possible variation of recharge from irrigation in Las Vegas Valley in the study years.

10. Two obvious problems are present in the budget, one of which is the "unaccounted for water" which is assumed to evaporate. This value alone is 13.3 percent of the total 1973 Valley budget. The other problem, that of establishing true consumptive use by lawn and agricultural crops is also unresolved and yields a potential error of 12 percent in the budget.

TABLE 1. POTABLE WATER USE IN LAS VEGAS VALLEY, 1973

	Usage in acre feet	% of Total
Residential lawn watering	30,000	21.0
Golf courses using potable water	5,500	3.0
Evaporative coolers	3,000	2.1
Swimming pools	600	0.4
Crop irrigation using potable water	2,600	1.8
Parks, schools, cemetaries, hotels, motels (lawns)	2,200	1.5
*BMI (industrial)	14,500	10.1
Nonmetered fire hydrants and System loss	10,500	6.3
Inhouse residential use	45,000	31.5
*Hotels and motels (inhouse use)	10,000	7.0
*Stores, offices	10,000	7.0
*Light industry	4,200	2.9
*Government buildings	4,900	3.4
TOTAL	143,000	99.9

* Division of Water Resources, State of Nevada records.

TABLE 2. RECHARGE FROM IRRIGATION

Year	Recharge Blaney-Criddle Method (consumptive use @ 3.47 ft/yr)	Recharge local agriculture experts (consumptive use @ 5.0 ft/yr)	Recharge Olivier Method (consumptive use @ 8.33 ft/yr)
1973	26,900 acre-ft	19,500 acre-ft	9,500 acre-ft
1965	14,900 "	9,800 "	4,200 "
1958	11,600 "	7,400 "	2,900 "
1950	9,300 "	4,800 "	1,100 "
1943	6,800 "	3,200 "	350 "

RECOMMENDATIONS

1. Monitoring Shallow Ground Water

The evidence developed in this study of continued net increase of shallow ground-water storage (conclusion #1) indicates the desirability of establishing a comprehensive monitoring program of the shallow ground-water system to provide the basis for future management decisions. Additional shallow ground-water monitoring wells should be installed throughout the area of urban development. Presently, there are very few suitable wells which can be used to monitor water level and water quality changes in the shallow ground-water system. If widespread changes are indeed occurring, they will in some areas have significant impact on 1) land uses and associated investments; 2) water quality in underlying developed aquifers; 3) location, amount and quality of shallow ground-water discharge, and 4) potential future use of these shallow ground waters for additional water supply.

2. Conservation

If or when water rates greatly rise in the future due to increasing energy costs and greater use of more costly Southern Nevada Water Project water, there may develop an opportunity to promote conservation of water by household users. For example: a family of four needs about 500 gal/day or 15,000 gal/month for general household uses. A minimum price per gallon could be set for the first 15,000 gal and then higher prices per gallon for water use over 15,000 gal in incremental steps. This would be equitable to low income families, provide incentive for careful water use, and could lead to significant savings particularly in lawn irrigation.

Another approach is an effort by local government and water agencies to promote esthetically acceptable water conservation landscaping, using suitable native vegetation instead of reliance on lawn grass for decorative purposes.

Consumptive use of trees has not been adequately researched in Las Vegas Valley. Research needs to be done to determine if the use of trees to cool single family residences is more efficient than the comparative power cost to cool unshaded residences. Some types of vines requiring limited watering may be more efficient for cooling of residences than trees.

3. Reuse of Wastewater

Wastewater can and has been used for irrigation purposes. However, at the present time (1977) only one golf course is using effluent water for irrigation. Winterwood golf course stopped using effluent in 1975 due to severe odor problems.

Research is needed on salt loading and odor problems that presently inhibits the use of sewage effluent for irrigation in populated areas. Possible research areas are 1) treatment and blending procedures for using treatment plant effluents and shallow, low quality ground water and 2) water quality requirements and potential demand of wastewater use for various industrial purposes.

BACKGROUND

Archaeological investigations have shown that Las Vegas Valley was occupied by aborigines as long as 10,000 years ago (Harrington, 1933). For centuries before exploration and settlement the Paiute Indian tribes occupied campsites near the springs of Las Vegas Valley (Haynes, 1967).

Las Vegas was probably first visited by Spanish explorers about 1770 (Haynes, 1967). From about 1830 until 1848, the springs in the Las Vegas Valley were a stopping place for Spanish caravans between New Mexico and California. The diaries of many early visitors (among them John C. Fremont on May 3, 1844) describe the Las Vegas Springs and associated meadows. The name Las Vegas was commonly applied by the early Spanish explorers and traders to meadows or green and fertile areas.

Mormon missionaries established a fort in Las Vegas in 1855 and developed farms using natural spring discharge (Jones and Cahlan, 1975). Alkali in the soil was a deterrent to successful farming, and this, coupled with internal dissension caused the mission to be abandoned in 1857.

According to a map drawn in 1855 by a Mormon settler, John Steele (Paher, 1971), there was a "tooley grass" area along Las Vegas Creek east of the Mormon Fort two and one-half miles long and about one-half mile wide. A mesquite "forest" extended from the area of the Mormom fort down Las Vegas Wash to the base of Frenchman Mountain and toward the Colorado River. According to this map, Las Vegas Creek did not flow to the Colorado River.

It is interesting to note that, based on tule consumptive use estimated for this study at 76 inches (6.33 feet) per year, the 1.25 square miles mentioned by John Steele would consume about 5,000 acre feet per year. The 1906 records of the Las Vegas Land and Water Company (Jones and Cahlan, 1975) describing flow of 6,400 acre feet per year from the springs feeding Las Vegas Creek suggest that discharge from Las Vegas Springs remained about the same for the 51 years from 1855 to 1906. Since consumptive use by tules and crop irrigation approximately equals spring production, it can be assumed that spring flow did not reach the Colorado River via Las Vegas Wash from 1855 to 1906.

Octavius Decatur Gass acquired the Mormon Fort in 1865 and, using irrigation water from Las Vegas Creek, developed a successful 640 acre farm and ranch he called "Las Vegas Rancho" (Figure 1). The ranch was sold to Archibald Stewart in 1882. In 1902 the land was sold to the San Pedro, Los Angeles and Salt Lake Railroad, later the Union Pacific Railroad, which in 1905 sold plots to develop the townsite of Las Vegas (Clark Townsite). The three largest springs in the Valley, called the Las Vegas Springs, were the principal water supply for the City of Las Vegas for many years.

Figure 1. Las Vegas, 1905-1909.

The other major ranch in Las Vegas Valley before the turn of the century was developed by Conrad Kiel and his sons. This 240 acres was on the site of one of the original Mormon farms and was irrigated from springs on the ranch, discharge being reported at 500 acre feet per year (Maxey and Jameson, 1948). In later years the spelling of the ranch was changed to Kyle. It was sold to the Utah, Nevada, and California Railroad Company in 1901. In 1907 it was purchased by John Park who drilled two wells and built two concrete reservoirs, one of which served as a swimming pool. In 1920 it became the Taylor Ranch and later was purchased by Edwin Losee.

Four years after the first well was drilled in 1907, there was a total of 100 wells within Las Vegas Valley, of which 75 flowed. Between 1911 and 1924, only 25 new wells were drilled due to a lack of interest in farming. These were mainly private residence wells. Between 1910 and 1924 about 22,400 acre feet per year of water were flowing from artesian wells and springs of which 2,240 acre feet per year were used for municipal supply and about 10,000 acre feet per year were lost from the uncapped artesian wells (Maxey and Jameson, 1948).

By 1934 the number of wells in the Valley had increased to about 275; in 1944 the total number of wells reached 450. By 1944 the flow from Las Vegas Springs had decreased to about 1,800 acre feet per year. Water levels continued to decline in the near surface zone and free flow from artesian wells had ceased due in part to decreased head and to a program of capping wells by the Division of Water Resources, State of Nevada (DWR).

A sewer system for the City of Las Vegas was built in 1912. Untreated effluent was discharged from a pipe at 9th Street and Bonanza and was used for irrigation of the Stewart Ranch, the old Las Vegas Rancho. The first sewage treatment plant for the City of Las Vegas was built in 1932 and located at Harris and 15th Street. An additional plant was built in 1942 at the corner of Harris and what is now Eastern Avenue. Their combined capacity was about two million gallons per day (mgd; 2,250 acre feet per year). Effluents from both plants were used to irrigate the Stewart Ranch. These plants were abandoned in 1950 after completion of a sewage treatment facility with a capacity of about four mgd (4,500 acre feet per year) at Harris and Manning Streets. Sewage effluent from this plant continued to be used for the irrigation of a ranch located near what is now the Winterwood golf course in the eastern part of the Valley. The present City of Las Vegas Sewage Treatment Plant (CLVSTP), located on Vegas Valley Drive, was built in 1958 with a capacity of about 12 mgd (13,500 acre feet per year). Effluent is still sold for agricultural use and power plant cooling. In 1967 the capacity was increased to 30 mgd (33,600 acre feet per year).

The Clark County Sanitation District Treatment Plant (CCSDTP) was built in 1955 with a capacity of 12 mgd (13,500 acre feet per year). The CCSDTP sells effluent water for agriculture, power cooling and golf courses.

Nellis Air Force Base used lagoons to evaporate sewage effluent from 1940 until 1971. After 1971, effluent from Nellis A.F.B. was piped to the CCSDTP and the Nellis sewage treatment system was dismantled. Sewage effleunt from the City of North Las Vegas is treated at CLVSTP.

Two treatment plants located near the Basic Management Incorporated (BMI) tailing ponds handle sewage from the City of Henderson and the BMI industrial complex. Effluents from these plants are spread in the upper and lower BMI tailing ponds located northeast of the City of Henderson near Las Vegas Wash.

In 1970 effluent from the Henderson Sewage Treatment Plant was measured at about 1,000 acre feet per year by personnel of the Water Resources Center (WRC), Desert Research Institute. In the same period, the BMI sewage treatment plant effluent was measured at about 1,800 acre feet per year for a total of 2,800 acre feet of sewage effluent spread in the upper and lower tailing ponds. These figures were used for 1973 budget calculations as population for the City of Henderson remained about the same as in 1970.

For purposes of this study Las Vegas Wash is divided into upper and lower reaches at Pabco Road in Henderson, the lower reach being from Pabco Road downstream to Lake Mead, the upper reach constituting the drainage above Pabco Road. Perennial flow in lower Las Vegas Wash began about 1944 fed by a ditch from the BMI plant (Stauffer Ditch) that bypassed the evaporation ponds (Figure 2) (G. B. Maxey, 1976, personal communication). Perennial flow in the upper Wash began in 1956 with completion of an outfall effluent line from the Harris and Manning Street sewage treatment facility to a ditch near the present CLVSTP site (Lou Anton, Superintendent of Sanitation, CLVSTP, 1973, personal communication).

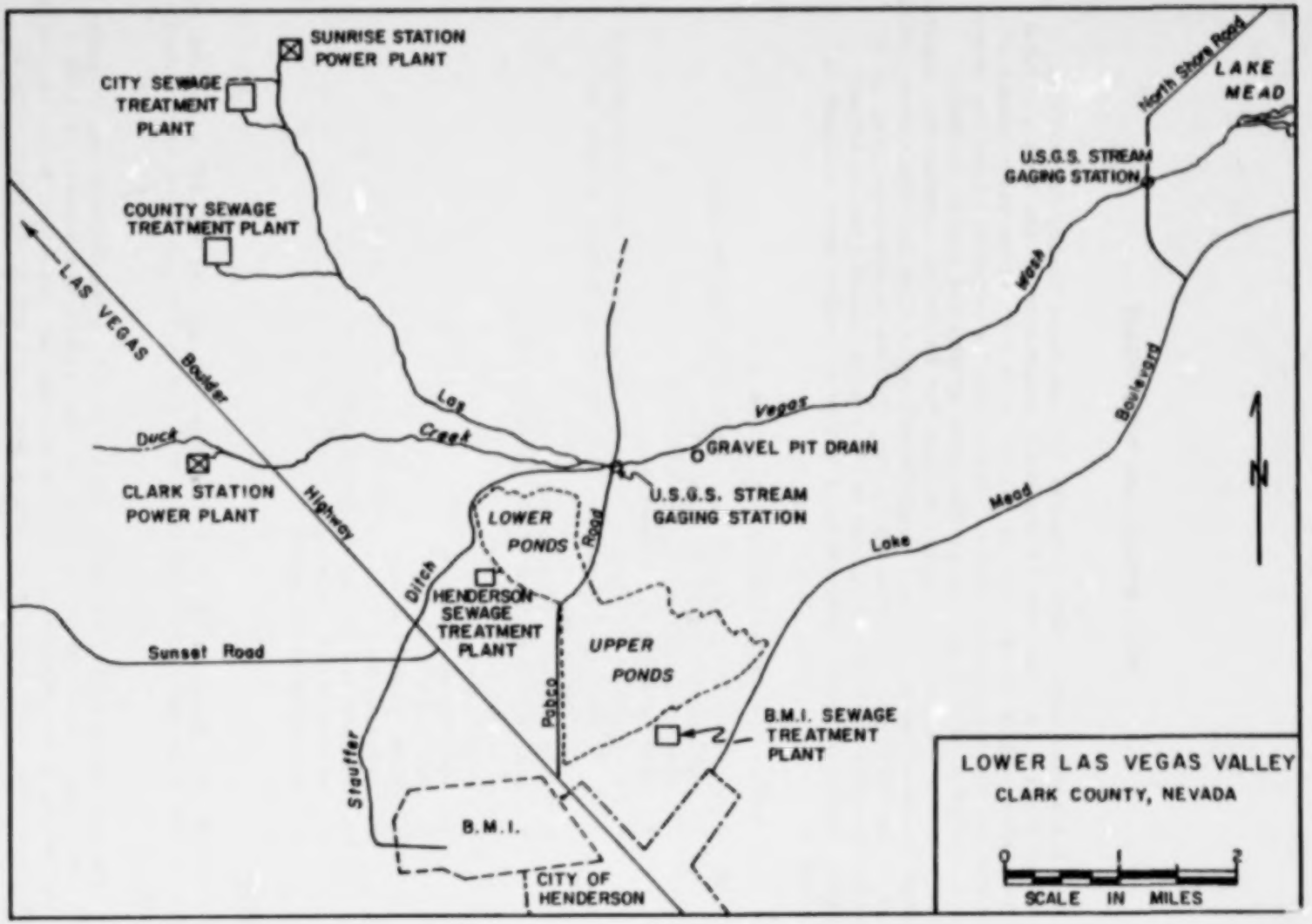

Figure 2. Lower Las Vegas Valley, 1965.

WATER BUDGET, LAS VEGAS VALLEY

A simplified water budget diagram for Las Vegas Valley for 1973 is shown in Figure 3 to demonstrate the basic components of the budget. Total Valley water supply to all uses is 143,000 acre feet after usage losses of evaporation and evapotranspiration; return flow is separated into two components, recharge to the shallow ground-water system and sewage effluent. These return flows then are separated into the following components: apparent change in ground-water storage, evapotranspiration from Las Vegas Wash, return flow to Lake Mead via Las Vegas Wash, and, shallow ground-water pumpage to account for that part of the ground-water supply coming from relatively shallow, domestic wells. Components of the water budget were analyzed as follows:

A. Supply from surface water and ground water

B. Consumptive use, applied use, evaporation and recharge.
   1. agriculture using potable water
   2. agriculture using sewage effluent
   3. lawn watering: residential
   4. lawn watering: parks, schools, cemetaries, hotels and motels (separated from residential water irrigation because of different application rates)
   5. golf courses using potable water
   6. golf courses using sewage effluent water
   7. septic tank recharge
   8. evaporative coolers
   9. transmission losses
   10. BMI industrial use
   11. power plant cooling
   12. swimming pool use
   13. consumptive use by phreatophytes
   14. precipitation recharge
   15. unaccounted-for water

SUPPLY

During 1973 total water use in Las Vegas Valley was 143,127 acre feet of which 73,370 acre feet were from Lake Mead and 69,757 acre feet were ground water.

The Las Vegas Valley Water District (LVVWD), a quasi-municipal corporation and largest distributor of water in the Valley, was created in 1948 by the Nevada State Legislature and encompasses Las Vegas and North Las Vegas. Although within LVVWD boundaries, North Las Vegas and Henderson maintain separate water delivery systems. Total water delivered by LVVWD during 1973

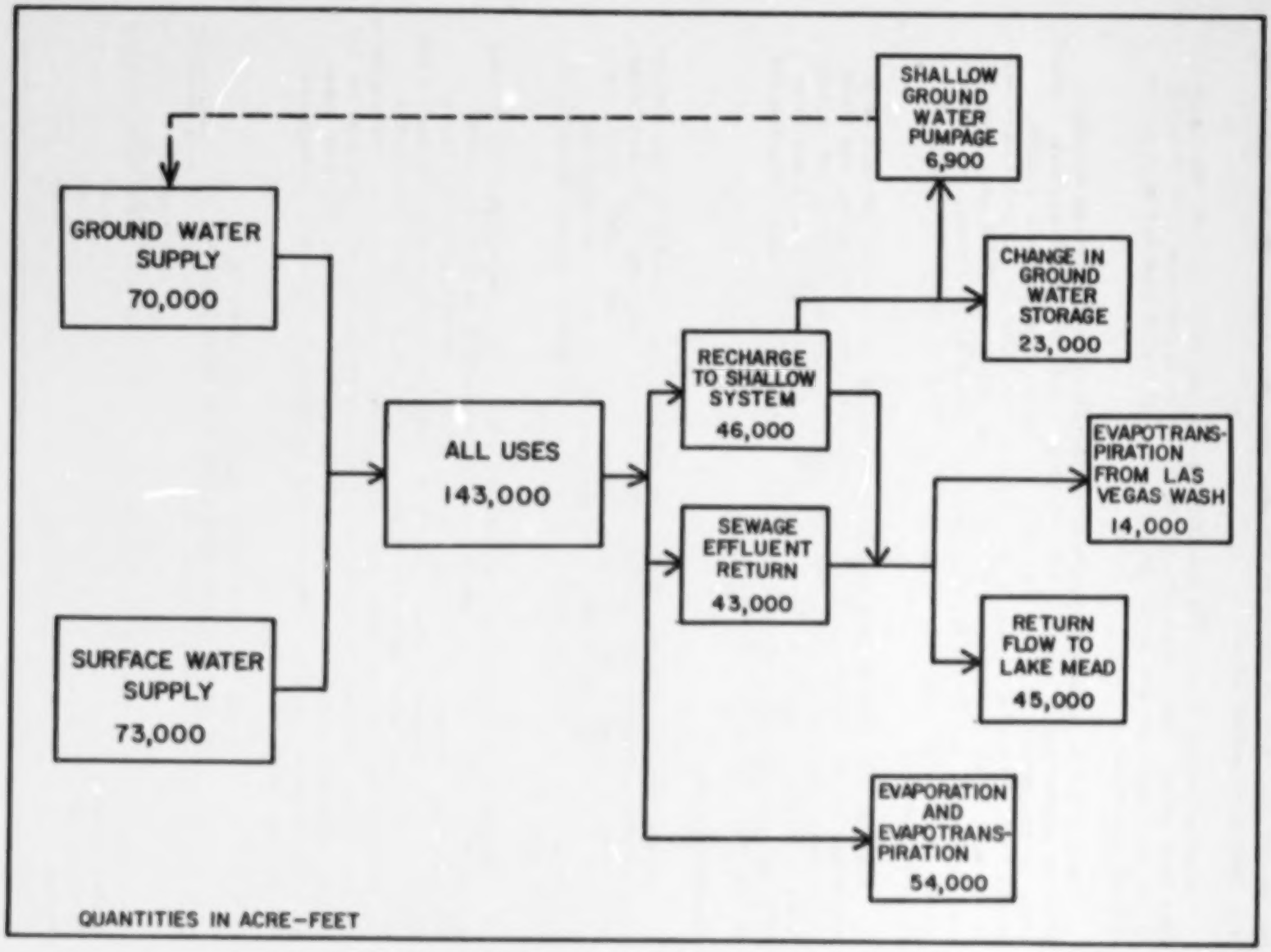
SHALLOW GROUND WATER PUMPAGE 6,900
GROUND WATER SUPPLY 70,000
CHANGE IN GROUND WATER STORAGE 23,000
RECHARGE TO SHALLOW SYSTEM 46,000
ALL USES 143,000
EVAPOTRANS-PIRATION FROM LAS VEGAS WASH 14,000
SEWAGE EFFLUENT RETURN 43,000
SURFACE WATER SUPPLY 73,000
RETURN FLOW TO LAKE MEAD 45,000
EVAPORATION AND EVAPOTRANS-PIRATION 54,000
QUANTITIES IN ACRE-FEET

Figure 3. Simplified Las Vegas Valley water budget, 1973.

was 81,977 acre feet of which 48,674 acre feet were from Lake Mead and 33,303 acre feet were ground water.

A water supply system for the BMI complex was built in 1942 utilizing Lake Mead water. Total delivery during 1973 was 21,089 acre feet of which 14,566 acre feet was for industrial use and 6,523 acre feet was sold to the City of Henderson.

Nellis A.F.B. owns and operates a water distribution system serving a military population of about 5,000 and about 5,000 civilian employees. Ground water in the amount of 1,848 acre feet was pumped from two well fields during 1973. One well field is on the Base, the other is located five miles to the west along Craig Road. During 1973 an additional 1,276 acre feet of Lake Mead water was purchased from Southern Nevada Water system, the governmental entity which supplies water from the Southern Nevada Water Supply Project (Phase I).

Pumpage from metered and unmetered wells, owned by small private water companies, major casinos, golf courses, trailer parks, and farms, was about 15,870 acre feet during 1973. Pumpage from the approximately 4,000 private domestic wells during 1973 was about 6,900 acre feet. These data are from DWR, inventory of Las Vegas Valley, 1973. Figure 4 shows water distribution in Las Vegas Valley by suppliers.

CONSUMPTIVE USE

Consumptive use by lawns in Las Vegas Valley was estimated by the Blaney-Criddle method (Blaney and Criddle, 1945). Using a seasonal crop coefficient of 0.99 for lawn grass in Las Vegas (Tovey, Spencer, and Muckel, 1969), consumptive use of domestic lawns, golf courses, parks, and cemetaries was estimated at 3.47 feet per year, with an assumed growing season of April 15 to October 15.

Published seasonal crop coefficients for alfalfa range from 0.85 (Blaney and Criddle, 1945) to 2.61 for an unirrigated, medium soil with a water table 2.0 feet below land surface (Tovey, 1963). According to Mr. Ferren Bunker, County Extension Agent-in-Charge, Cooperative Extension Service, University of Nevada, Reno (personal communication, 1973), lawns and alfalfa in Las Vegas Valley have about the same seasonal consumptive use. For purposes of this study, consumptive use by alfalfa was considered to be the same as for lawns. Possible differences in consumptive use by different types of grass were not studied. Table 3 compares four methods of estimating consumptive use for Las Vegas Valley.

TABLE 3. CONSUMPTIVE USE OF LAWN GRASS IN LAS VEGAS VALLEY USING FOUR DIFFERENT METHODS

	Consumptive Use in ft/yr
Blaney-Criddle	3.47
Thornthwaite	3.67
Penman	6.66
Olivier	8.33

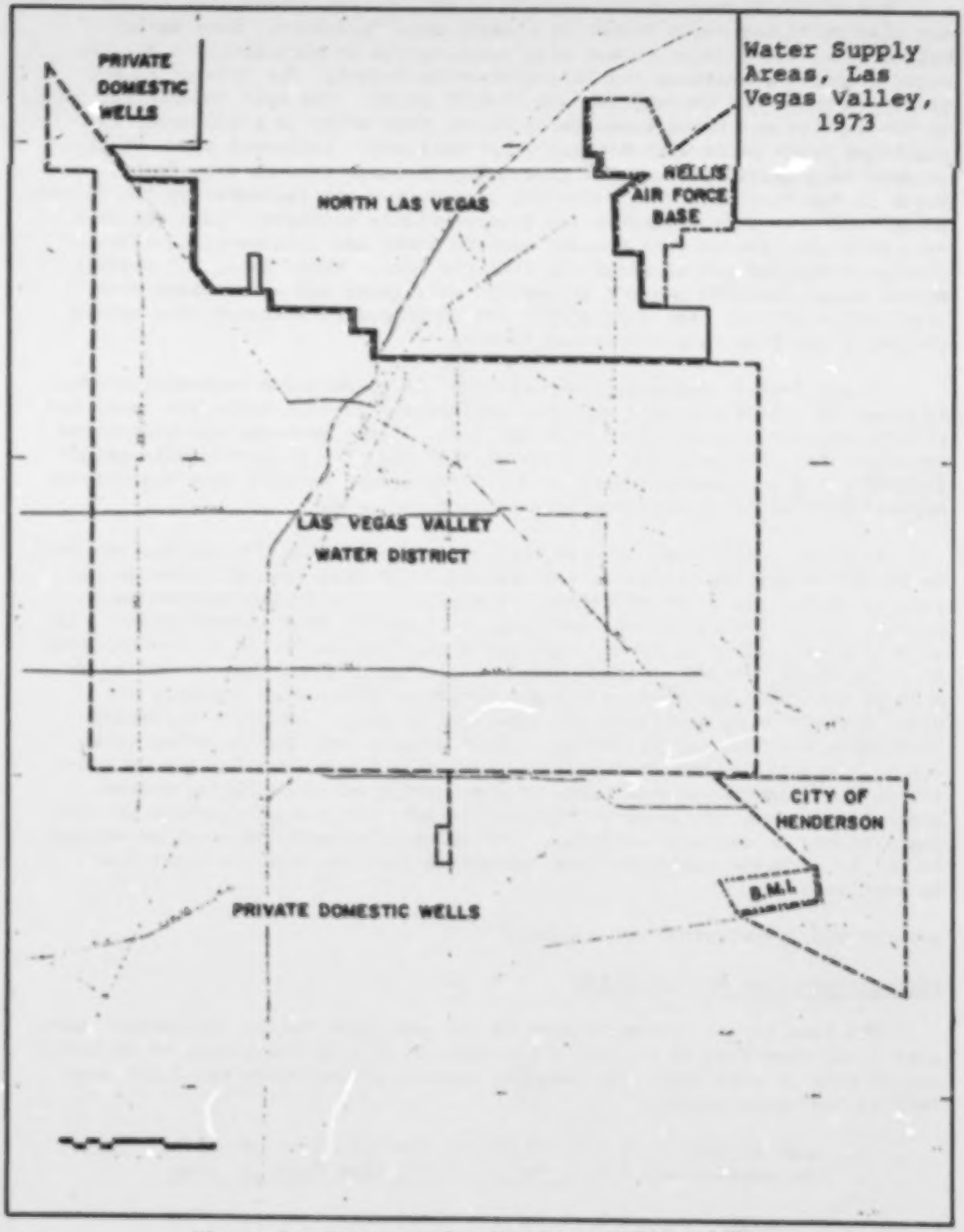

Figure 4. Water supply, Las Vegas Valley, 1973.

Use of the Blaney-Criddle method for determining consumptive use of lawns and alfalfa in Las Vegas Valley is clearly open to debate. Some experts believe that the Olivier method of consumptive use is more accurate for Las Vegas climatic conditions than Blaney-Criddle method. The Olivier method gives a much higher consumptive use of 8.33 ft/yr. The best independent check on consumptive use rates encountered during this study is a sub-study of eight Las Vegas parks with metered water delivery. Irrigated areas planimetered from aerial photographs give an application rate of 6.31 ft/yr, which is two feet less than potential consumptive use estimated by the Olivier method and 2.84 feet more than the Blaney-Criddle estimate. Less reliable data from golf course well pumpage records (DWR) and planimetering also indicated applied use at about six feet per year. Thus, using the Olivier method would mean 100 percent irrigation efficiency and no recharge with application of less than 8.33 ft/yr. It is therefore believed this method yielded a too high consumptive use figure.

Ferren Bunker (personal communication, 1976) believed consumptive use is about five feet per year and that optimum application rates for lawns and alfalfa should be about seven feet per year. Since recharge was calculated by substracting consumptive use from applied use, the Blaney-Criddle method yielded a higher recharge value of 27,000 acre feet in 1973 than the Olivier method which would yield 9,500 acre feet of recharge.

As it is considered unlikely that potential consumptive use was two feet in excess of application rates and because 9,500 acre feet of recharge per year is judged low based on general knowledge of the shallow ground-water system, Blaney-Criddle values have been utilized in this investigation. In view of the independent check developed during the study, it is now believed that the Blaney-Criddle method yielded a consumptive use that is low by as much as two feet, and that calculated recharge values were probably too high, perhaps by as much as 8,000 acre feet in 1973. However, differing conditions such as soil variations, plant density and health, water table depths, consumptive use of infiltrated water by trees, variability in growing season (irrigation does occur to some extent at times during winter months) and variation in crop coefficients make precise calculation of consumptive use an unlikely exercise. Use of the Blaney-Criddle method should result in recharge estimates from irrigation that are clearly upper limit in magnitude.

APPLIED USE, EVAPORATION AND RECHARGE

Agriculture Using Potable Water

One farm in the northwest area of the Las Vegas Valley (Gilcrease Ranch) used 2,460 acre feet of potable well water in 1973 on 396 acres, or an application rate of 6.21 feet. Recharge to shallow ground water was 1,100 acre feet as indicated below:

applied use	@ 6.21 ft/yr	= 2,500 acre feet per year
consumptive use	@ 3.47 ft/yr	= 1,400 acre feet per year
recharge	@ 2.74 ft/yr	= 1,100 acre feet per year

(acre feet values have been rounded)

Agriculture Using Sewage Effluent

Five farms in the southeast area of Las Vegas Valley were reported (DWR) to have used 4,511 acre feet of effluent on 1,160 acres (WRC) in 1973; an application rate of 3.88 ft/yr.

	Acre feet
LDS Church Farm	2,731
Stout Farm	292
CLV Rehab. Farm	629
Pat McDowell Ranch	784
Stewart Bros. Ranch	75
TOTAL	4,511

A high water table (less than or equal to 10 feet below land surface) in this area should reduce surface water demand by a phreatophyte crop such as alfalfa, and possibly explains the reduced water usage as compared with potable water use for agriculture. Another explanation for this seemingly low water usage was erroneous data. Recharge to shallow ground water was 500 acre feet as indicated below:

applied use @ 3.88 ft/yr = 4,500 acre feet per year
consumptive use @ 3.47 ft/yr = 4,000 acre feet per year

recharge @ 0.41 ft/yr = 500 acre feet per year

Residential Lawn Watering

A transportation study map developed in 1965 for the Clark County Regional Planning Commission by Wilbur Clark Associates divides the Valley into numbered zones generally bordered by major streets (Figure 5). In that study a dwelling unit count was obtained from United States Census Bureau data that was updated to 1973 with local building permit data for each zone. This provides an accurate data base of dwelling units per zone. Through use of color infrared aerial photos, flown by the National Aeronautics and Space Agency (NASA) in October of 1971, average area of lawns, percentage of dwelling units with lawns, total lawn areas for cemetaries, parks, schools, hotels, motels, industry, and hospitals were estimated by rough measurement of green areas for each of these zones. Representative areas were then field checked for accuracy of aerial photo derived estimates. These estimates were then adjusted to 1973 levels based on building permit data. Appendix 1 presents these data by zone number.

LVVWD delivered 36,260 acre feet of water to 42,250 single unit dwellings from July 1972 through June 1973. The least amount of water delivered for any month (February) during that period was 1,535 acre feet. Assuming this value represents base monthly in-house use (minimal lawn watering), multiplying by 12 months and subtracting from the total delivery, 17,840 acre feet is estimated to have been applied to lawns. Average lawn size of representative areas for single family dwelling units in the LVVWD service area is estimated from the NASA aerial photographs to be 1,500 square feet. Average lawn size

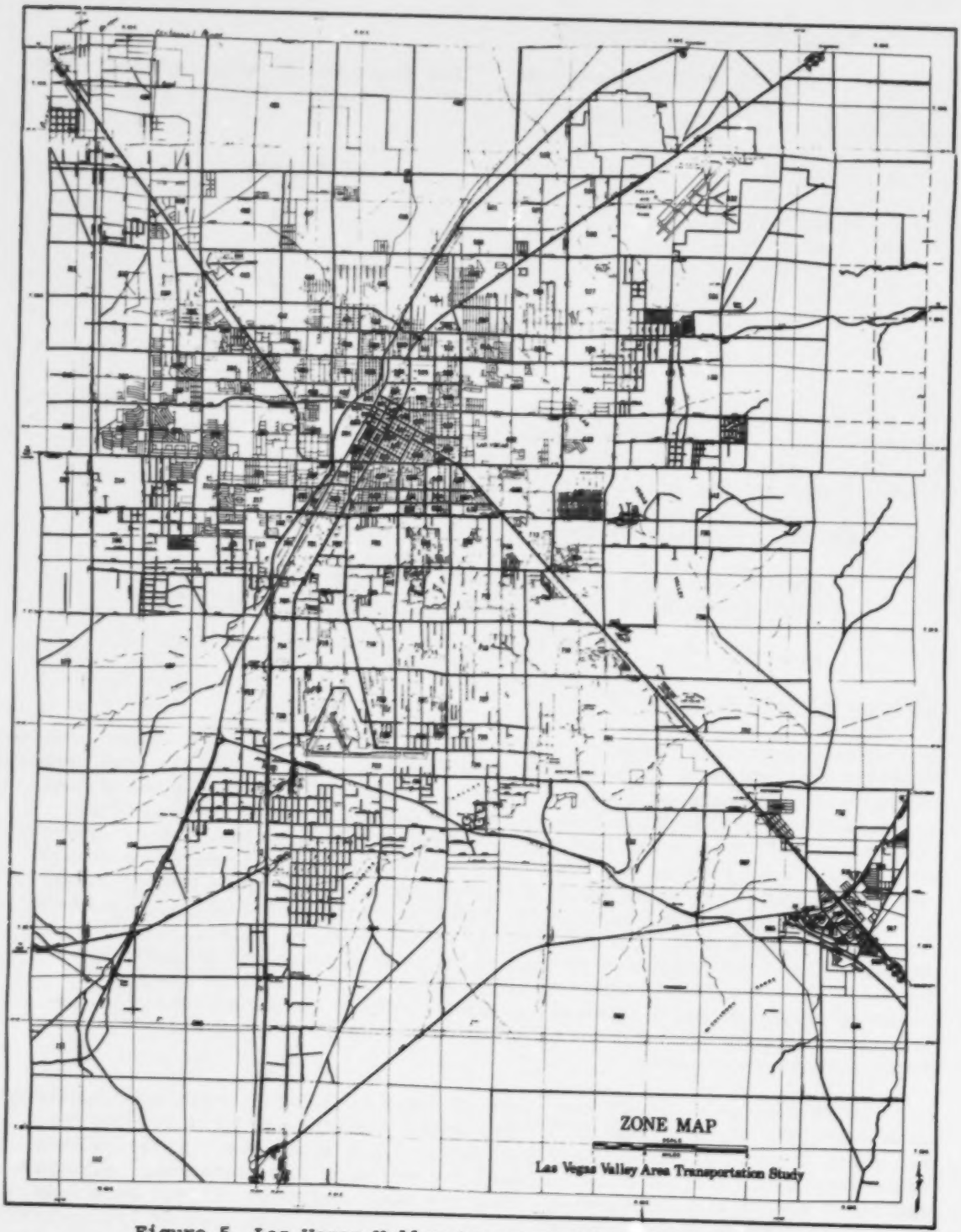

Figure 5. Las Vegas Valley transportation study zones.

for the entire Las Vegas Valley is estimated to be 1,000 square feet per dwelling unit, including apartment complexes. Apartments average 500 square feet of lawn per dwelling unit. From the above, it is estimated that 12.26 feet of water were applied to lawns in the LVVWD service area. Recharge of 8.79 feet is calculated by subtracting the consumptive use of 3.47 feet from the estimated application of 12.26 feet. Total residential lawn area in the Valley is estimated at 2,431 acres. At an applied rate of 12.26 ft/yr, total applied use is calculated at 30,000 acre feet per year. Recharge from residential lawn watering of 8.79 ft/yr is estimated at 21,500 acre feet per year.

For comparative purposes and to further determine an approximate range of lawn water application, data for 19 single family dwellings in the LVVWD service area were developed by interviewing owners and measuring lawn size (Table 4). Water billings were provided by the LVVWD. In-house use ranged from 41 gallons per day (gpd) per person to 221 gpd per person and average 108 gpd per person. Owners verified they did not water their lawns during the base month used to calculate in-house use. For these homes, lawn applications ranged from 7.67 feet to 45.7 feet and average 14.7. If the highest value is disregarded, average application is 13.0 feet. This derived use rate agrees very well with the previously derived value of 12.26 ft/yr residential use for the entire Valley.

Condominiums studied had separate metering for their sprinkler irrigation systems. Lawn applications ranged from 5.5 feet to 13.5 feet for the period July 1972 through June 1973. Average application was 9.1 feet (Table 5) which is 30 percent less than estimates for lawns at individual residences. This may be a result of separate metering for the sprinklers, professional gardening, or a combination of same.

TABLE 5. TOWNHOUSE METERED WATER CONSUMPTION FOR LAWN WATERING 1972

	Acres in lawn	Applied rate in ft/yr
Desert Spa	20	13.53
Georgetown West	4.8	9.14
Bradford Place	0.7	8.06
Greenbriar	17.4	5.52
AVERAGE		9.05

Parks, Schools, Cemetaries, Motels, Hotels, Hospitals and Industrial Lawns

During 1973, LVVWD metered water deliveries to eight parks in the Valley. Average application rate determined for these parks is 6.3 ft/yr (Table 6). Data from these parks are used to estimate an application rate which could reasonably be applied to all park, school, cemetary, motel, hotel, hospital and industrial lawn areas in the Valley.

TABLE 4. CONSUMPTIVE USE DATA FOR REPRESENTATIVE SINGLE FAMILY DWELLINGS IN LAS VEGAS VALLEY

Name	Address	Occupants	Total metered wtr consump 1973 in gal	Months lawn was watered	Hr per week of watering	Use in gal when lawn was not being watered	Yearly in house use in gal	Lawn wtr use in gal	Size of lawn in sq ft	Application rate in feet per year	Per person use in house per day in gal
Feeney	1648 La Jolla	4	317,000	8	2	53,000	159,000	158,000	2,750	7.7	108.9
Parise	1600 La Jolla	4	540,000	7	2	135,000	324,000	217,000	3,200	9.0	220.9
Scott	1616 La Jolla	6	335,000	8	1	72,000	216,000	119,000	1,500	10.6	98.6
Fresch	1611 La Jolla	3	294,000	8	1	16,000	48,000	246,000	3,300	10.0	43.8
Barker	1627 La Jolla	2	395,000	7	2	41,000	98,000	297,000	2,500	15.9	134.2
Sterner	1645 La Jolla	2	54,000	0	0	-	54,000	0	0	0	73.9
Thornton	1664 La Jolla	6	477,000	9	10	84,000	168,000	309,000	900	45.9	76.7
Danielson	1037 Howard	3	264,000	8	1	49,000	147,000	117,000	800	19.5	134.2
Hins	1029 Howard	2	281,000	8	7	22,000	66,000	215,000	1,750	16.4	90.4
Inman	1025 Howard	5	360,000	7	7	57,000	136,800	223,300	2,250	13.3	74.9
Oakes	1043 Howard	3	324,000	11	1	9,000	108,000	217,000	1,700	17.1	98.6
M.J. Lowry	1055 Howard	3	330,000	6	4	61,000	122,000	208,000	2,000	13.9	111.4
Lowry	1046 Howard	5	106,000	6	7	31,000	62,000	75,000	900	11.1	41.1
Walsh	1060 Howard	2	435,000	10	4	19,000	115,000	320,000	2,400	17.8	156.2
Edmunds	1067 Howard	5	459,000	11	4	18,000	217,000	242,000	2,400	13.5	119.9
Starr	1071 Howard	1	137,000	5	1	27,000	46,285	90,715	1,250	9.7	136.8
Doig	1066 Howard	2	190,000	5	7	46,000	78,857	154,000	2,500	8.2	108.0
Licciardo	1044 Howard	2	96,000	0	0	-	96,000	0	0	0	131.5
Strubelt	1077 Howard	2	232,000	8	1	21,000	63,000	179,000	2,350	10.2	86.3
			(Average for ft/year does not include 2 desert landscaping homes)							14.7	107.7

TABLE 6. RECORDED WATER USE OF EIGHT PARKS IN LAS VEGAS VALLEY, 1973

Park	Gallons* applied		Acres†
Squires	14,905,000		5.7
Gray Dexter	8,185,000		4.1
Hyde Park	9,859,000		4.5
Huntridge Circle	6,762,000		3.2
Doolittle Park	27,003,000		13.06
Baker Park	9,647,000		4.9
Jaycee Park	17,839,000		7.62
Hadland Park	20,098,000		12.5
TOTAL	114,298,000	(350.7 acre feet)	55.58
applied use = 6.31 ft/yr			

*Metered water records for LVVWD.

†Planimetered green areas.

It appears that lawns of Table 6 received more professional gardening and a more conservative application rate because of economic factors. This lower application rate (6.31 ft/yr) is assumed to be a realistic estimate for this category of lawn in Las Vegas.

Total acreage for lawns of this type obtained from aerial photographs was 353.61 acres. Recharge to shallow ground water was 1,000 acre feet as indicated below:

applied use @ 6.31 ft/yr = 2,200 acre feet
consumptive use @ 3.47 ft/yr = 1,200 acre feet

recharge @ 2.84 ft/yr = 1,000 acre feet

Golf Courses Using Potable Water

Table 7 lists golf courses using potable water in Las Vegas Valley, their acreage, and amounts of water applied for irrigation during 1973. Golf course areas were planimetered from aerial photographs. In most cases, volumes of water applied were from DWR records. Quantities of water use for Black Mountain and Nellis golf courses are estimates provided by the respective greenkeepers. Quantities for North Las Vegas and Aladdin golf courses are based on average unit application rates for the other courses.

TABLE 7. GOLF COURSE IRRIGATION USING POTABLE WATER IN LAS VEGAS VALLEY, 1973

Golf Courses Using Potable Water	Area (Acres)	Volume of Irrigation Water (acre ft/yr)	Unit Rate of Application (ft/yr)
Aladdin	8	47.14*	5.89
Black Mountain	80	920.70*	11.51
Craig Road	86	335.42	3.90
Desert Inn	131	624.28	4.77
Dunes	124	829.98	6.69
International	145	927.97	6.40
Las Vegas Municipal	111	299.85	2.70
Nellis	62	484.92*	7.82
North Las Vegas Municipal	13	76.60*	5.89
Sahara Nevada	126	759.94	6.03
Tropicana	49	248.60	5.07
TOTAL	935	5555.40	
AVERAGE	5555.40 ÷ 935	=	5.94

*Estimated volume.

Total volume of potable water applied to golf courses during 1973 was 5,500 acre feet. Estimated recharge to shallow ground water was 2,300 acre feet as indicated below:

applied use @ 5.94 ft/yr = 5,500 acre feet
consumptive use @ 3.47 ft/yr = 3,200 acre feet

recharge @ 2.47 ft/yr = 2,300 acre feet

Golf Courses Using Sewage Effluent Water

Table 8 lists the two golf courses in Las Vegas Valley that used treated sewage effluent in 1973, their acreages, and amounts of water applied for irrigation. Volume of water applied comes from DWR records. Golf course areas are planimetered for aerial photographs.

TABLE 8. GOLF COURSE USE-RATES OF TREATED EFFLUENT

Golf Courses Using Treated Effluent	Acres	Vol. or Irrigation Water (acre feet)	Unit Rate of Application (ft/yr)
Paradise	94	710.86	7.55
Winterwood	109	495.94	4.55
TOTALS	203	1,206.80	
AVERAGE	1,206.80 ÷ 203	=	5.94

Total area of golf courses using sewage effluent was 203 acres. Volume of sewage effluent applied was 1,200 acre feet. Water for both golf courses was purchased for the CCSDTP.

Estimated recharge to shallow ground water was 500 acre feet as indicated below:

applied use	@ 5.94 ft/yr =	1,200 acre feet
consumptive use	@ 3.47 ft/yr =	700 acre feet
recharge	@ 2.47 ft/yr =	500 acre feet

Septic Tank Recharge

Septic tank leach fields are a source of direct recharge to the "near surface" zone. Clark County Health Department has maintained records on septic tanks since 1954. However, locations are sometimes inexact and there are no records to show homes previously on septic tanks which connect as sewer service expands. Although dwelling units within 400 feet of sewer lines are required to connect (Clark County Ordinance 109), this rule is not always enforced. Therefore, to obtain pre-1954 data and more precise locations, aerial photographs and telephone company criss-cross directories for 1943, 1950, 1958, 1965, 1970, and 1972 have been used to count dwelling units more than 400 feet from sewer lines that existed at the time the aerial photographs were taken. This method yields 3,096 homes on septic tanks in 1970 versus 2,974 according to a United States Census Bureau count for the same period. Appendix 2 lists septic tanks and populations by the zones as shown in Figure 5. Figures 6, 7, 8, 9, and 10 show septic tank areas in Las Vegas Valley in the years 1973, 1965, 1958, 1950, and 1943, respectively.

According to 1970 data, per capita wastewater flow in Henderson, North Las Vegas, and unincorporated areas ranged from 100 gpd to 133 gpd. Cohn (1966) states there is no "standard" per capita sewage flow and such flows from single family dwellings may be in the range of 75 gpd to 125 gpd. The United States Census Bureau (1970) shows an average of 3.1 persons per single family dwelling with septic tanks in Las Vegas Valley, serving about 12,400 people. Therefore, recharge to the "near surface" zone from septic tanks has been estimated to be about 1,750 acre feet. Consumptive use of septic

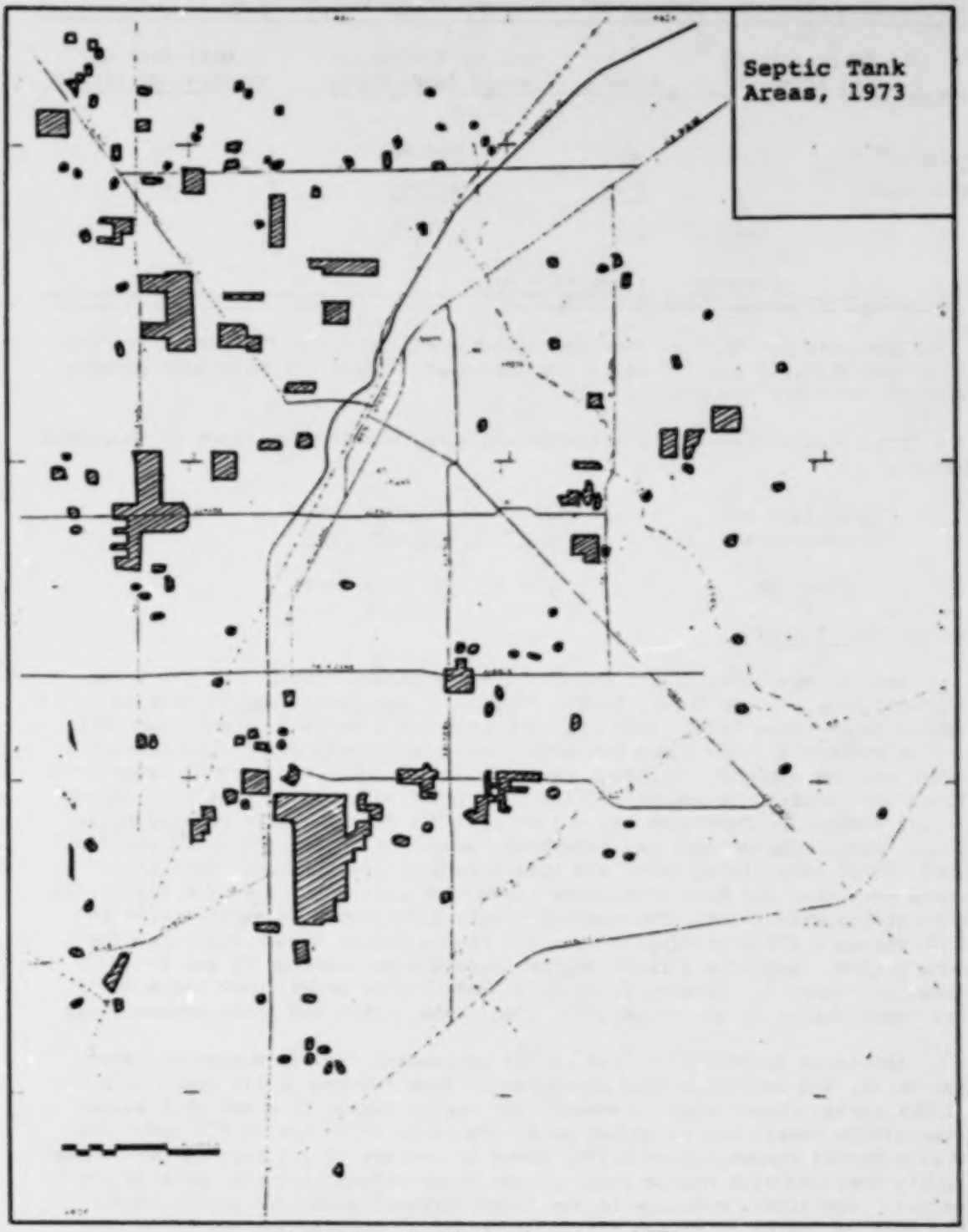

Figure 6. Septic tank areas, 1973.

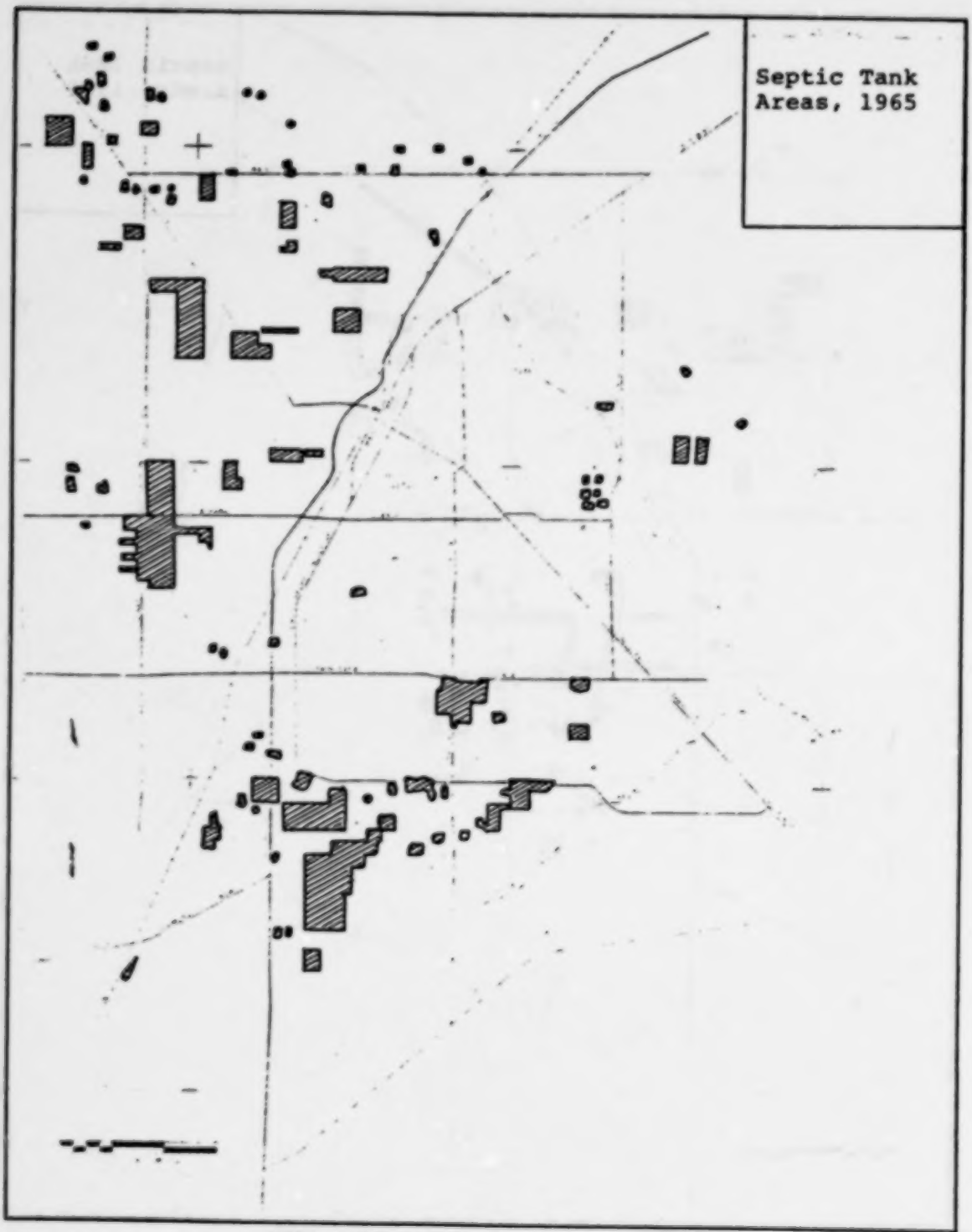

Figure 7. Septic tank areas, 1965.

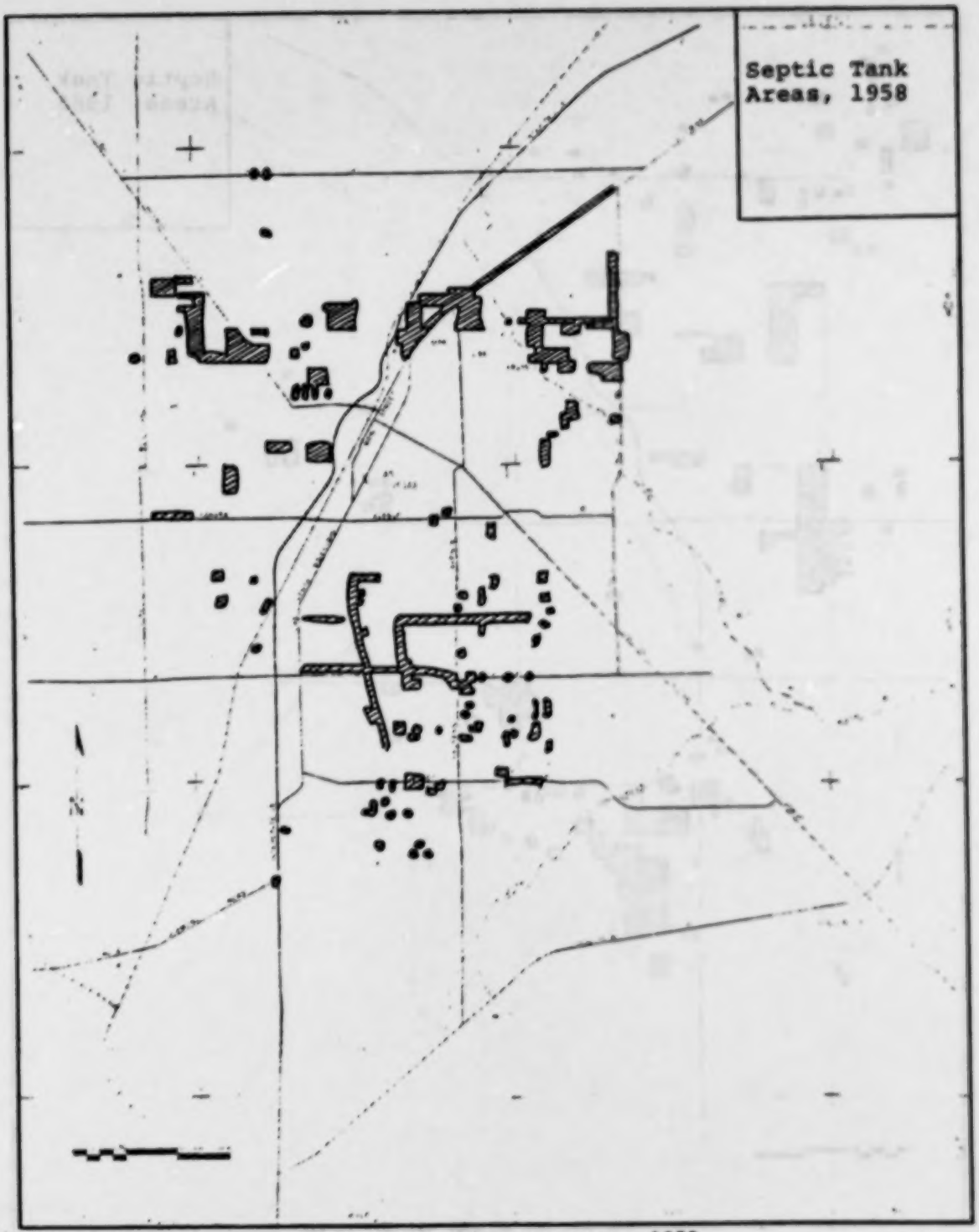

Figure 8. Septic tank areas, 1958.

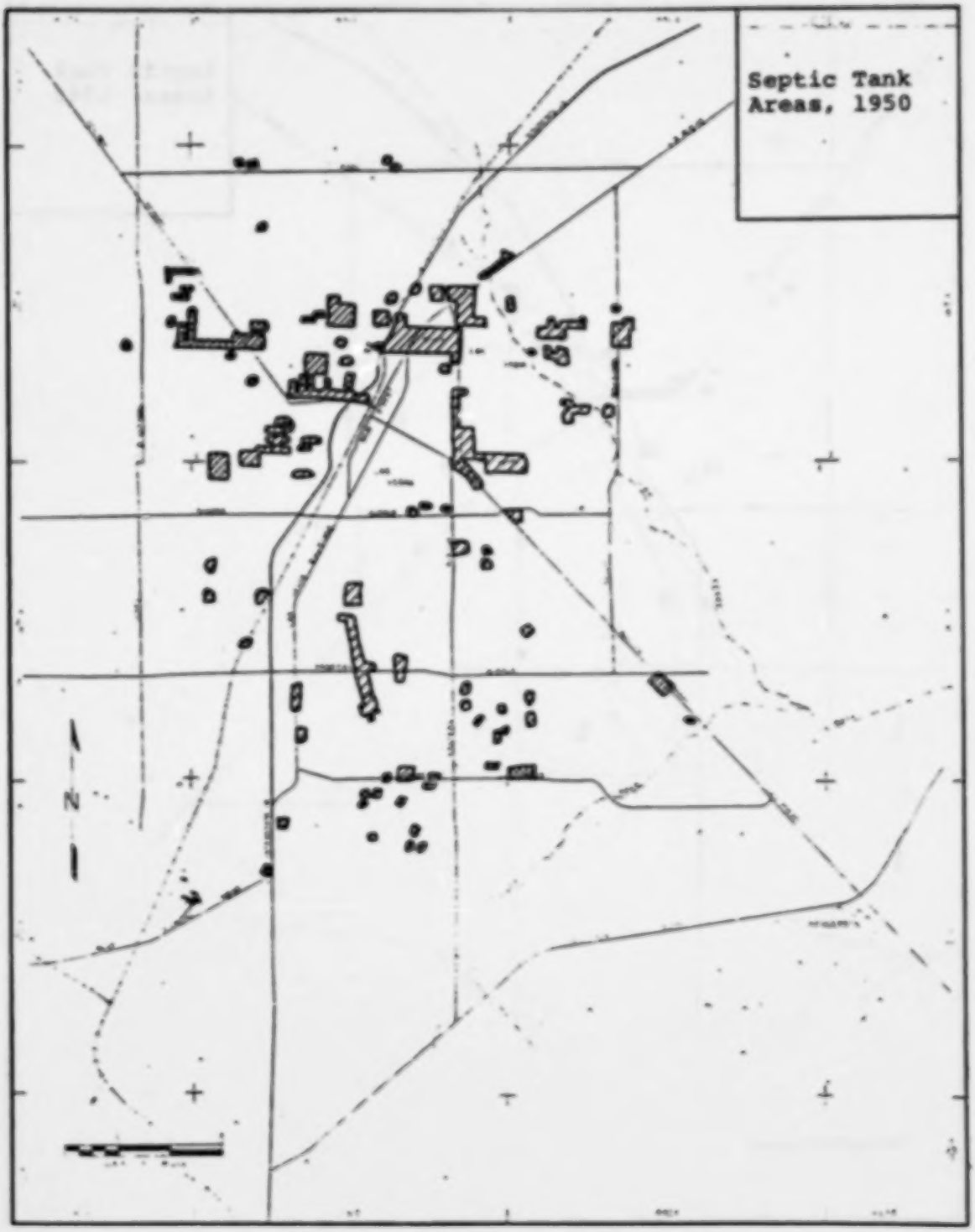

Figure 9. Septic tank areas, 1950.

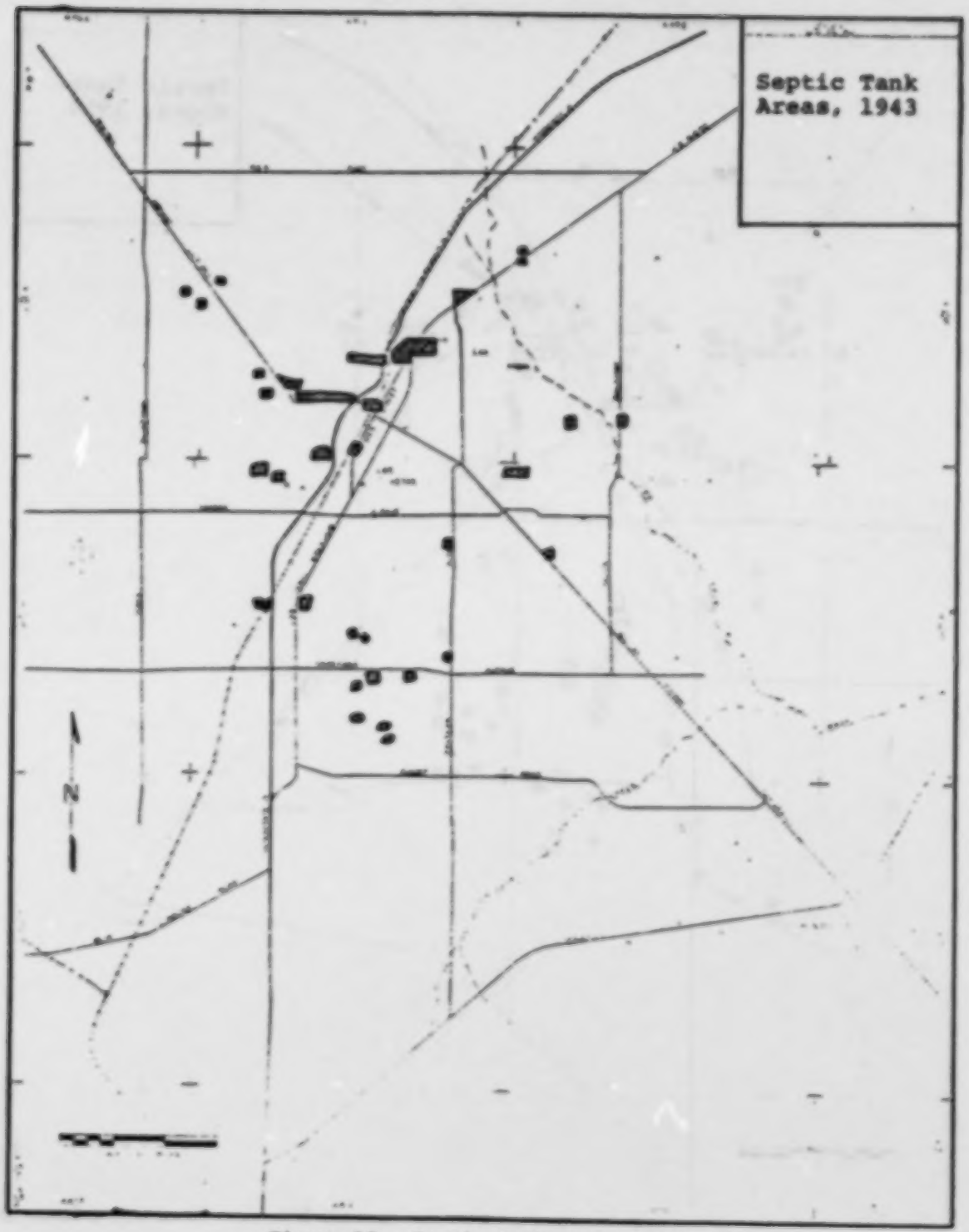

Figure 10. Septic tank areas, 1943.

tank effluent by trees near the leach fields would decrease this recharge volume but no attempt has been made to quantify this factor.

Evaporative Coolers

In 1970, according to the Census Bureau data, there were 23,283 dwelling units using evaporative coolers. No data was available on industrial use. Relatively few evaporative coolers have been installed since 1964 because FHA and VA policy has been to discourage this type of cooling unit, therefore, the number of units estimated in 1970 has been applied to 1973. An evaporative cooler evaporates approximately 240 gallons of water a day for 180 day/year, an average of 43,200 gallons/year (Aldo Barozzi, Assistant to General Manager, LVVWD, 1973, personal communication). Use of 23,283 units consuming 43,200 gallons/year accounts for 3,000 acre feet per year of evaporative loss.

A previous study which considered water use of evaporative water coolers showed an average use of 120,000 gallons/year (Cochran and Wilson, 1971). These were coolers without recirculating pumps in Boulder City, Nevada. An ordinance passed in Las Vegas in 1965 requires recirculating pumps as a water conservation measure.

Transmission Loss

Transmission loss reflects apparent water loss from meter error, water main breaks, system leakages, unauthorized use of water taps from hydrants, flushing of fire hydrants, street cleaning, etc. Transmission losses recorded for the LVVWD delivery system during 1973 were 9.82 percent of total metered supply. In a study of transmission loss done by Keller (1970) 354 selected utilities reported an average loss of 10.90 percent. Losses in the 10-20 percent range were considered reasonable.

Transmission loss for 1973 is estimated by applying the measured percentage system loss of the LVVWD (9.82 percent) to the total amount of water pumped or purchased by the various municipal water delivery systems in the Valley (LVVWD, NLV, Hend., Nellis AFB):

$$105{,}800 \times 0.0982 = 10{,}500 \text{ acre feet}$$

Mr. Aldo Barozzi, Assistant to the General Manager of the LVVWD, states that he believes about 25 percent of the transmission loss goes to recharge due to leakage and main breaks and about 75 percent is evaporated (personal communication, 1976). Recharge to shallow ground water is estimated as 2,600 acre feet as indicated below:

recharge	25% x 10,500 acre feet = 2,600 acre feet
evaporated	75% x 10,500 acre feet = 7,900 acre feet

Basic Management Incorporated (BMI)

BMI imported 14,500 acre feet of Lake Mead water for industrial use in 1973. About 400 acre feet of cooling water was discharged directly to Las Vegas Wash. In 1971 recharge in the BMI ponds was estimated to be 10,500

acre feet and evaporation was estimated at 420 acre feet (Westphal and Nork, 1972). Since 1971 water importation to BMI (14,000 acre feet) was approximately the same as 1973, it is assumed that recharge and evaporation remained fairly constant. The unaccounted for water (3,200 acre feet) probably reflects chemical fluid production, manufacturing and in-plant evaporation.

Power Plant Cooling

Treated effluent is used for cooling purposes at the two Nevada Power Company power generation stations in the Valley. During 1973, 1,120 acre feet of effluent from CLVSTP and CCSDTP were used at Sunrise Station and 2,590 acre feet from CCSDTP were used at Clark Station (DWR data). Nevada Power Company estimates that about 75 percent evaporated and 25 percent or approximately 900 acre feet was discharged to Las Vegas Wash.

Swimming Pools

There were 4,004 swimming pools in Las Vegas Valley in 1971 as counted from the NASA color-infrared photographs (Appendix 3). By the end of 1973, an additional 1,600 permits for pool construction (not including above ground pools) had been issued. Assuming 5,600 pools with an average surface area of 400 square feet, and averaging 5.0 feet deep, annual filling would account for 257 acre feet. Annual evaporation based on average annual Boulder City corrected pan evaporation of 80 inches using a pan coefficient of 0.7 (Westphal and Nork, 1972) would account for 343 acre feet for a total of 600 acre feet evaporation from swimming pool use and season-end drainage. There is some question as to whether application of the pan coefficient is justified due to heated pools and as to design and amount of drainage. It is interesting to note that swimming pools are relatively insignificant users of water regardless of the estimate uncertainties. They are generally considered to be a high user by the public. It appears that swimming pools use about the same amount of water as the lawn they generally replace.

Phreatophyte Consumption

Discharge losses in Las Vegas Wash resulting from consumptive use by phreatophytes and free surface evaporation are obtained by modifying monthly use values previously calculated by WRC (Westphal and Nork, 1972). In that study, approximate evapotranspiration (ET) losses along the Wash were estimated using the Blaney-Criddle method. Estimated FT was 81 inches per year for salt cedar and 76 inches per year for tules. Using a 1970 area of phreatophyte growth along the Wash of 2.84 square miles, estimated annual ET was 9,800 acre feet. To update this value, 1973 aerial photos of the Wash have been used and a new total phreatophyte area of 2.95 square miles determined, yielding a new annual ET of 10,300 acre feet. This rate is divided into ET above and below Pabco Road based on percentage distribution of phreatophytes. Each of these values is then divided into twelve monthly rates using the average percentage distribution of annual pan evaporation for the Las Vegas area. A small component to account for free surface evaporation is then added to each value as appropriate, based on estimated open water area and local free surface evaporation rates.

Annual consumptive use in the reach above Pabco Road is calculated at 5,800 acre feet and for the reach below Pabco Road at 4,500 acre feet. In the area near the CLVSTP and CCSDTP, mesquite is the dominant phreatophyte. Gatewood (1950) reports annual consumptive use of mesquite near Safford, Arizona, which is comparable in climate to Las Vegas, is 3.3 ft/yr. Therefore, for a phreatophyte area of 1,048 acres, evapotranspiration in the area near the Las Vegas Sewage Treatment Plan is estimated to be 3,500 acre feet per year. Total evaporation from Las Vegas Wash is estimated at 13,800 acre feet in 1973. Phreatophyte consumption estimates for other areas of the Valley are not attempted. Phreatophyte consumption is of course dependent on density of plants as well as total area. As no attempt is made to compare densities, values estimated are subject to considerable error.

Precipitation Recharge

Average annual precipitation in Las Vegas Valley is approximately 3.7 inches per year. Much of this precipitation is derived from moderate to high intensity rain storms with resulting high runoff rates. Under predevelopment conditions in the Valley, efficient overland flows of surface runoff and only minor infiltration along washes probably characterized the situation in much of the present developed area of Las Vegas Valley. However, development of the characteristic urban sprawl of Las Vegas has greatly modified the natural runoff characteristics (Kaufmann, 1976). The net effect is much greater opportunity for some portion of this water to be recharged to the shallow ground-water system. There is no direct or reliable way to estimate this recharge with existing data.

Tom McIntyre of the United State Soil Conservation Service (personal communication, 1976) estimates that about two percent of rainfall in Las Vegas Valley is recharged, and this seems reasonable based on Kaufmann (1976) water quality evidence. Using a Valley area of 256,000 acres and an average of 0.31 feet of precipitation, this estimate suggests that approximately 1,600 acre feet is recharged from this natural source each year. As there is no quantitative basis for the two percent figure, this estimation may be subject to substantial error.

Unaccounted for Water

Figure 11 is a more detailed water budget diagram than was shown in Figure 3 for 1973. All components differentiated in this study have been included in the diagram. In the third row from the top, a box entitled "unaccounted water" with a magnitude of 19,000 acre feet occurs. The "unaccounted water" box (Figure 11) shows volumes not accounted for in the categories listed and therefore is the difference between total water delivered and the sum of the remaining component uses plus sewage return flows. It includes such unaccountable items as evaporation from residents and tourists, cooking, water storage facilities, washing, and industrial uses, as well as error related to underestimating component uses or overestimating supply.

The following considerations lead to determination of the "unaccounted for water." By adding up known and estimated delivery components:

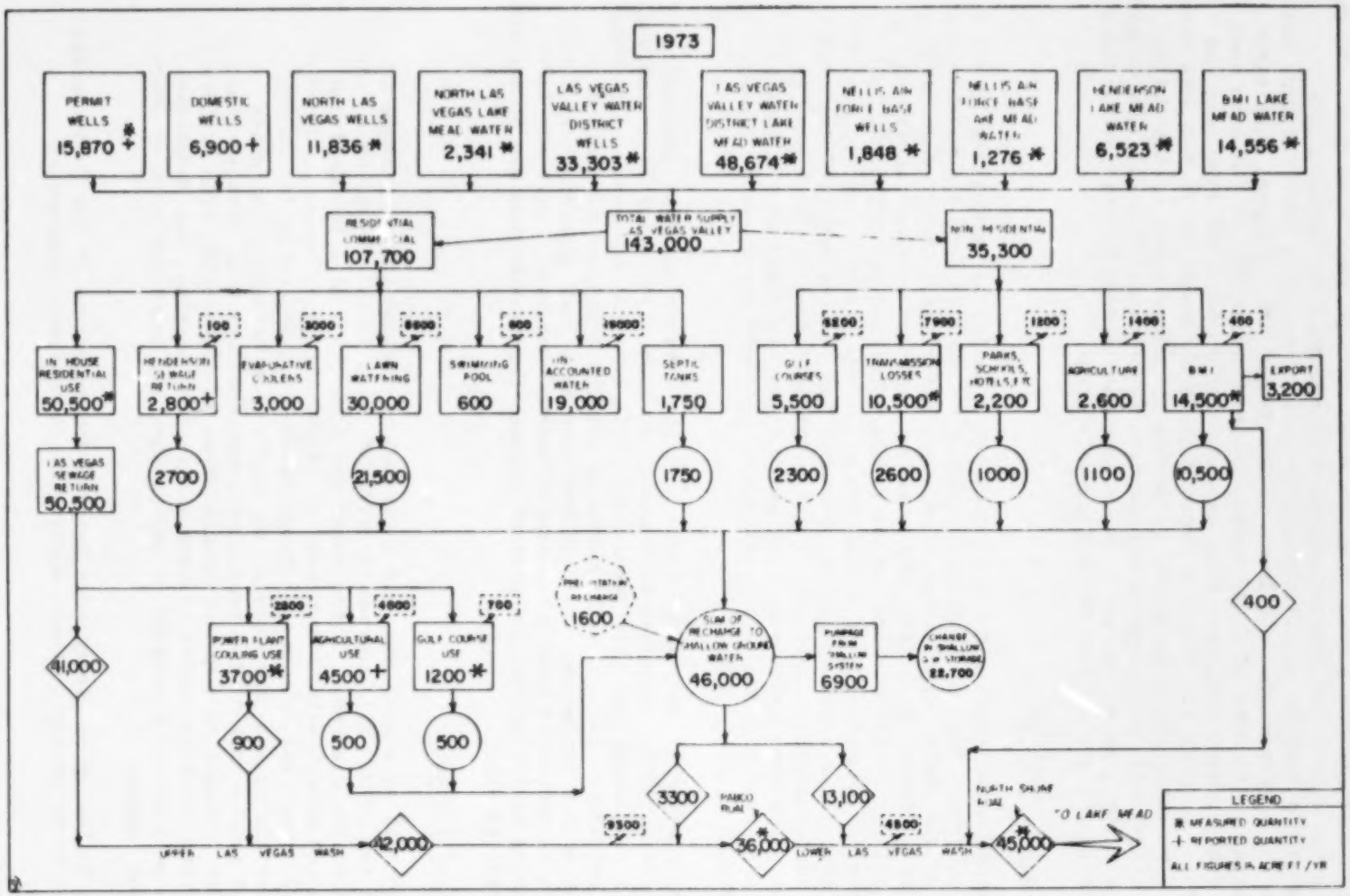

Figure 11. Water budget for Las Vegas Valley, 1973.

1.	Agriculture potable water	2,600 acre feet
2.	Golf courses using potable water	5,500 acre feet
3.	Transmission loss	10,500 acre feet
4.	Parks, schools, cemetaries, hotels, motels and industrial lawns	2,200 acre feet
5.	BMI	14,500 acre feet
	TOTAL	35,300 acre feet,

and subtracting from the total delivery of 143,000 acre feet, 107,700 acre feet are estimated to be remaining residential, government, commercial, and industrial delivery. Industrial export from the BMI industrial complex is estimated by subtracting measured outflow from measured inflow. Known and estimated deliveries and uses from this 107,700 acre feet are:

1.	Septic Tanks	1,750 acre feet
2.	Evaporative coolers	3,000 acre feet
3.	Lawn watering	30,000 acre feet
4.	Swimming pools	600 acre feet
	TOTAL	35,350 acre feet.

The total of sewage return flows are:

1.	Las Vegas Sewage Treatment Plant	35,500 acre feet
2.	Clark County Sewage Treatment Plant	15,000 acre feet
3.	Henderson and BMI Sewage Treatment Plants	2,800 acre feet
	TOTAL	53,300 acre feet.

Adding the above two totals of deliveries and sewage return yields the total accounted for water of the 107,700 acre feet of water:

Deliveries	35,350 acre feet
Sewage return	53,300 acre feet
TOTAI	88,650 acre feet

Therefore, "unaccounted for water" becomes:

	107,700 acre feet
-	88,650 acre feet
TOTAL	19,050 acre feet

This water is assumed to be some combination of evaporated water, underestimated error in uses, or overestimated error in supply.

BUDGET DESCRIPTION

As demonstrated in a simplified budget diagram in Figure 3, the sources, distribution, and disposition of water in Las Vegas Valley are elaborated in more detail in Figure 11 for 1973, and for earlier years of 1965, 1958, 1950, and 1943, in Figures 12, 13, 14, and 15, respectively. These diagrams demonstrate recorded and estimated use components, estimation of evaporation and evapotranspiration, estimations of recharge to shallow ground water, sewage return flow and sewage use, recorded flow of Las Vegas Wash, and estimations of precipitation recharge.

The budget diagrams are designed to demonstrate supply sources (top row), residential use and non-residential use (2nd row), disposition of supply (third row), recharge estimates to shallow ground water (fourth row), and return flow disposition (lower part of the diagram). Components dealing with recharge to the shallow ground-water system are indicated by circles, whereas components reflecting surface water flows are indicated by diamond shaped boxes. Evaporation or evapotranspiration is indicated by dashed rectangles.

The lower portion of the budget diagrams generally lays out the disposition of return flows (sewage effluent, ground-water discharge, and other wastewater). In 1973, sewage flow from the CCSDTP and the CLVSTP is 50,500 acre feet; 9,400 acre fee is diverted for agriculture use, power cooling and golf course irrigation before it reaches the stream gage on Las Vegas Wash at Pabco Road (Figure 2). About 900 acre feet of cooling water returns to the Wash and an estimated 9,300 acre feet is lost to phreatophyte evapotranspiration before Las Vegas Wash surface return flow reaches the gage at Pabco Road. Comparing the sum of these flows in to measured discharge at Pabco Road gives a deficit of 3,300 acre feet. The 3,300 acre feet deficit is balanced by shallow ground-water inflow to the Wash. The validity of this addition is demonstrated by Kaufmann (1976), who indicates there is upward ground-water movement in the area, and by Bateman (1976) who independently calculated a ground-water return of 2,200 acre feet in the reach above Pabco Road.

Figure 16 is a recharge contour map of Las Vegas Valley for 1973. To construct this map the recharge data developed in preceding sections were plotted on a grid composed of squares 1000 feet on each side to form grid nodes, and then contour lines were drawn using the node point values of recharge. Areas of greatest recharge occur in the BMI tailing ponds where at least 20 ft/yr of recharge occurred in the ponds receiving wastewater. Golf courses, parks and agriculture areas using potable water show recharge of about three feet per year. Residential areas show recharge from 0 to 2 feet per year. Although residential areas use about 12 feet of water per year, the non-irrigated areas such as streets, houses, and sidewalks decrease the per unit area recharge rate to below the rate of concentrated irrigation areas such as parks, golf courses and agriculture.

The pattern of recharge is irregular and widely distributed in the Valley. Kaufmann (1976) has demonstrated the water quality influence of such recharge, but little data is available to clearly demonstrate, on a Valley-wide basis, the changes that may be occurring in water tables and associated ground-water storage. The influence of the industrial wastewater effluent of the BMI complex has been documented in the southeastern part of the Valley,

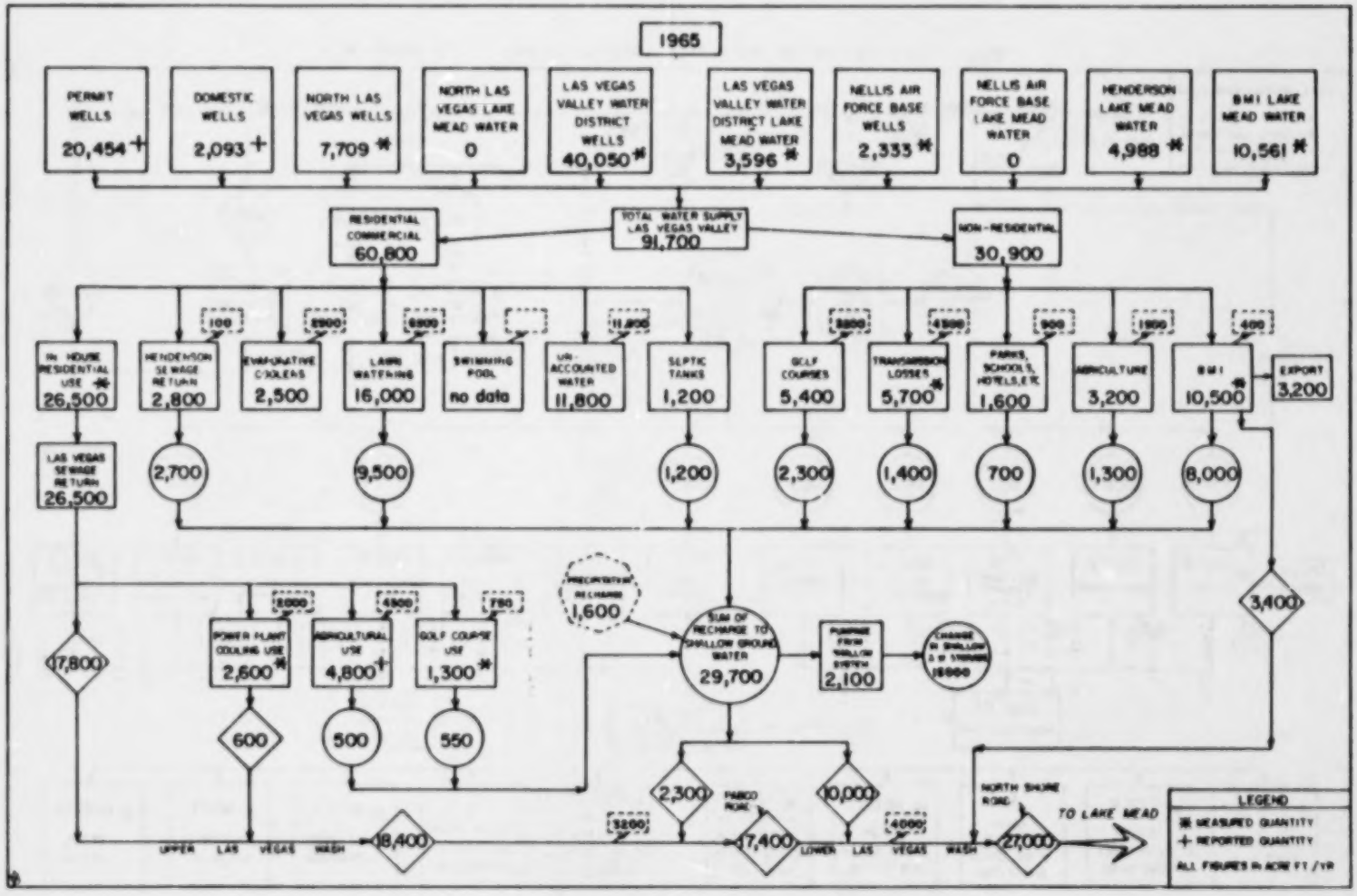

Figure 12. Water budget for Las Vegas Valley, 1965.

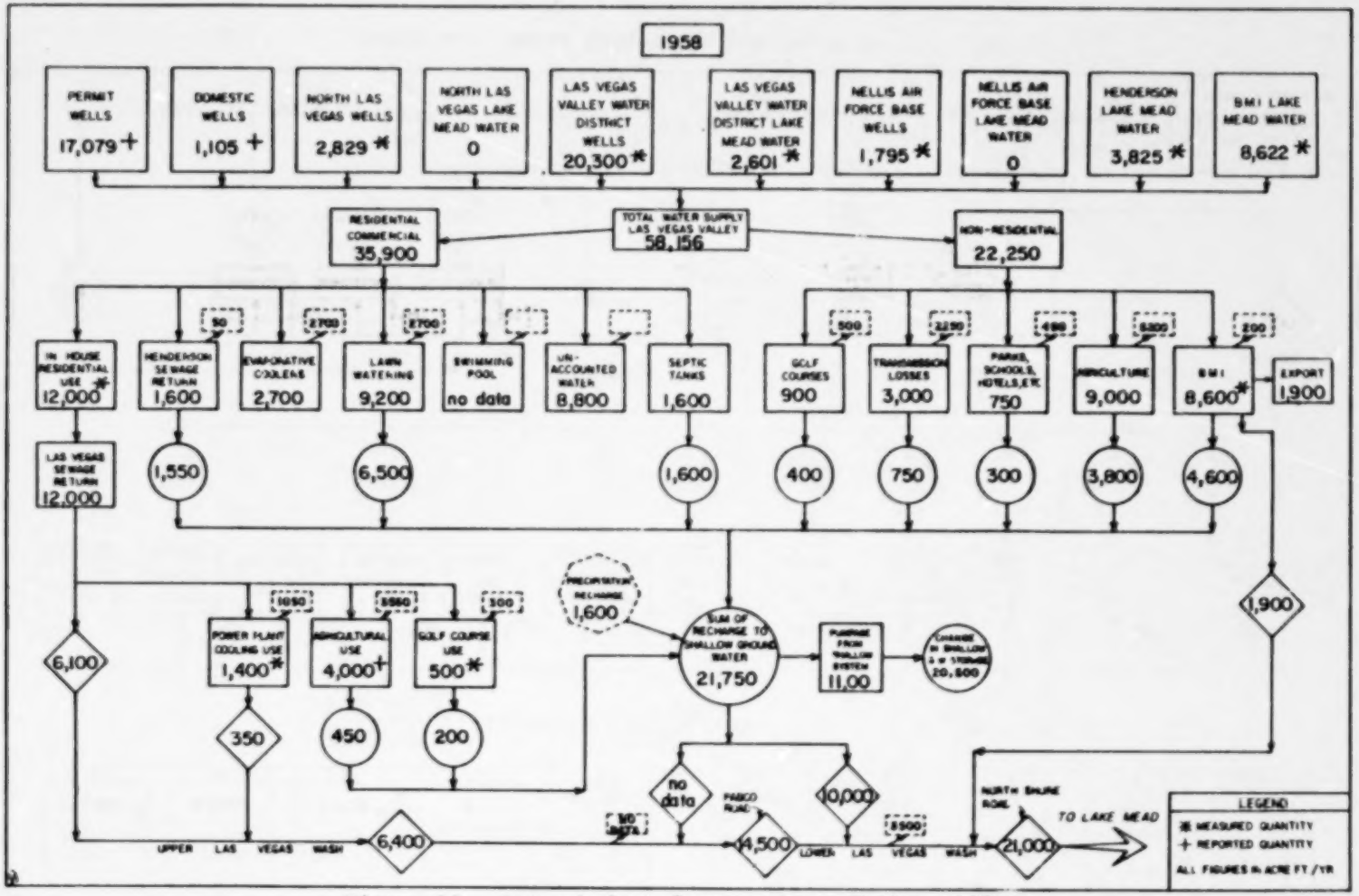

Figure 13. Water budget for Las Vegas Valley, 1958.

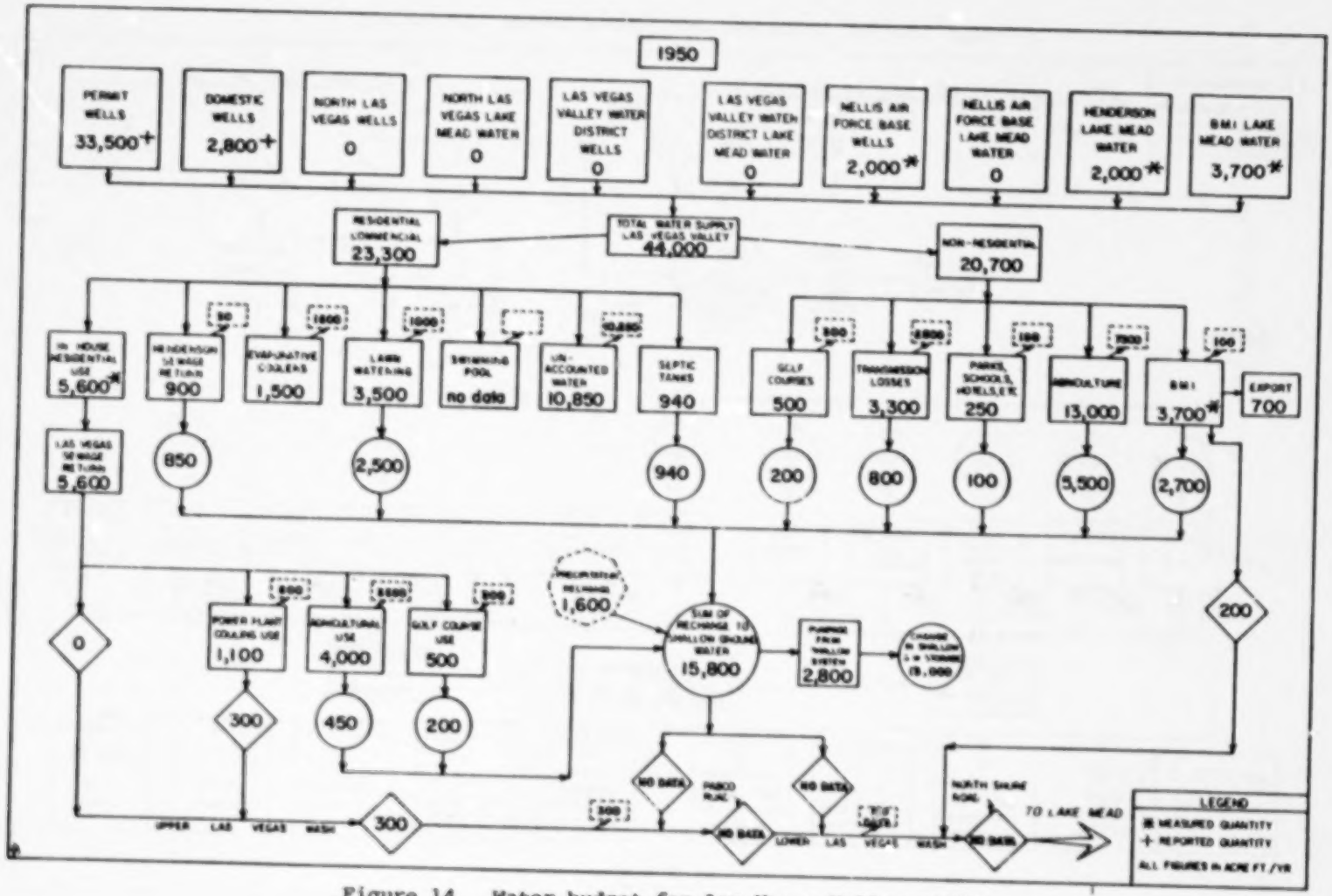

Figure 14. Water budget for Las Vegas Valley, 1950.

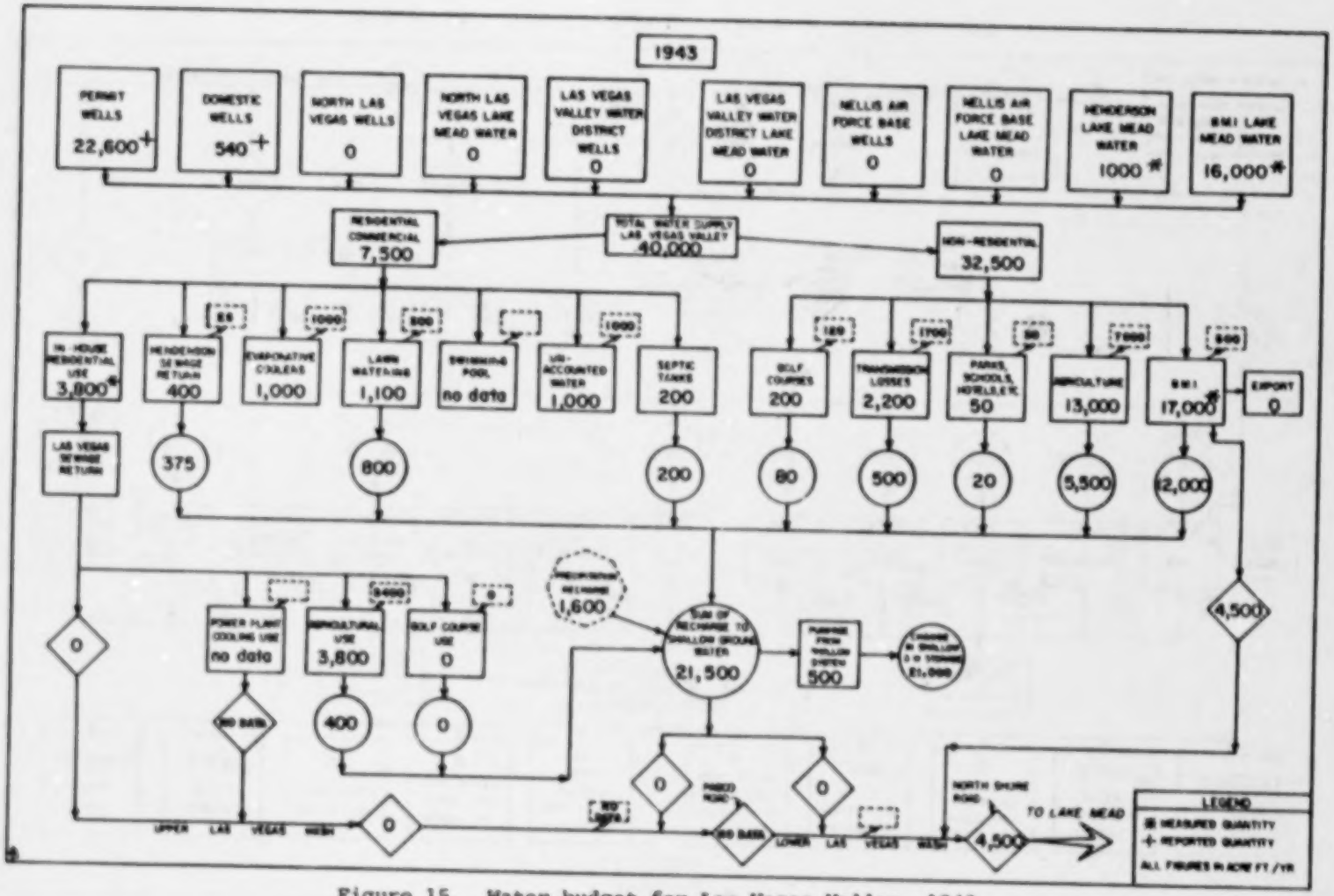

Figure 15. Water budget for Las Vegas Valley, 1943.

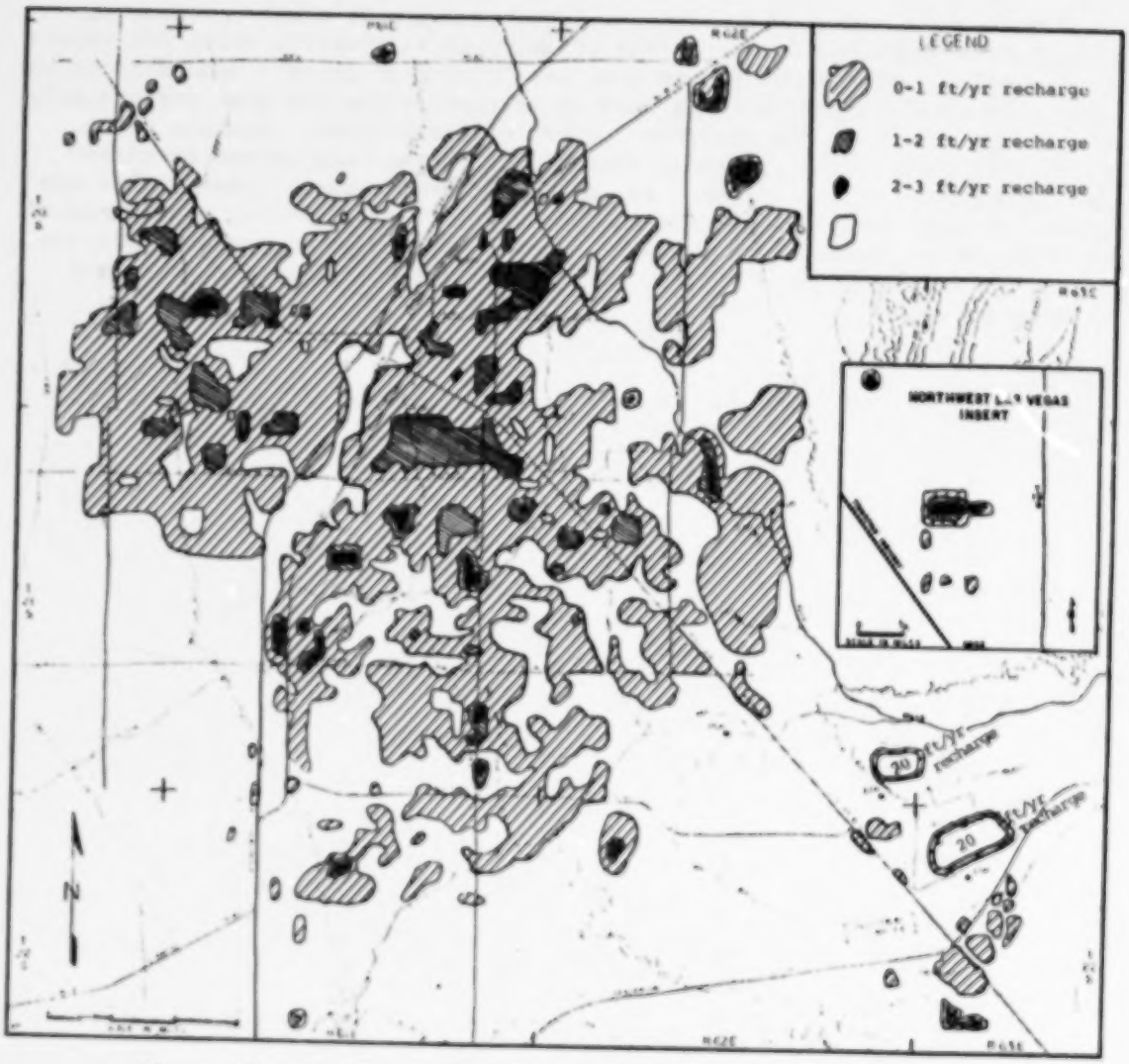

Figure 16. Recharge contour map of Las Vegas Valley, 1973.

and shallow water table conditions have developed in the LDS farms area of the upper Las Vegas Wash. In other areas, there is less firm evidence for significant storage changes in the shallow system, and base line data to compare changes are rare to absent. Some original shallow saturation areas were probably due to predevelopment ground-water discharge.

The budget analyses also indicate that changes in shallow saturation should be occurring. For each year of analysis, a positive value for change in storage in the shallow system results. Figure 16 clearly demonstrates why long term increase in shallow ground-water storage has not been particularly noticeable except in the above-mentioned localized areas. Shallow wells, perforated only in the uppermost zone of saturation, are generally absent throughout much of the Valley. Based on this study, where water tables are presently near land surface (see Kaufmann, 1976), rising water tables might be expected to increasingly cause problems as continued increased water use occurs in the Valley, and shallow saturation gradually rises to near land surface positions.

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Appendix 1. Dwelling Unit Count and Lawn Acreage for Dwelling Units, Cemetaries, Parks, Schools, Motels, Hotels, Hospitals and Industrial Areas, By Zones

JUNE 1973 DWELLING UNITS

CLARK COUNTY REGIONAL PLANNING BOARD

LAS VEGAS VALLEY WATER DISTRICT

Zone	Dwelling Units	Sq. Ft. Avg. Lawn	% With Lawn	Total Sq. Ft. of Lawns	Cemetaries, Parks, Schools	Industrial Hotels Motels Hospitals	Sq. Ft. Total Lawns	Total Acres
101	84	100	90	7,560	0	10,000	17,560	.4
102	682	2000	80	1,091,200	130,680	6,000	1,227,880	28.17
103	465	1500	90	558,000	0	30,000	588,000	13.49
104	1389	1500	70	1,458,450	591,500	0	2,049,950	47.06
105	682	2000	90	1,227,600	0	0	1,461,600	28.18
106	31	1500	90	41,850	5,000	0	46,850	1.08
107	128	1000	80	102,400	5,000		107,400	2.47
108	2	1000	1000	2,000	0	0	2,000	.04
109	308	1000	80	24,640	0	0	24,640	.36
110	0	1000	100	0	0	0	0	0
111	0	500	100	0	0	0	0	0
112	0	500	100	0	0	0	0	0
201	0	0	0	0	0	3,000	3,000	.06
202	0	0	0	0	0	0	0	0
203	984	1500	90	1,060,800	6,000	0	1,066,800	24.49
204	963	2000	80	2,600,100	653,000	0	3,253,100	74.68
205	879	1500	80	105,480	196,200	0	1,250,800	28.71
206	1589	1500	80	1,906,800	105,000	0	2,011,800	46.18
207	2036	1500	80	2,443,200	40,000	0	2,483,200	57.01
208	1316	1800	80	1,895,040	25,000	0	1,920,040	44.08
209	0	0	0	0	0	0	0	0

June 1973 Dwelling Units
Clark County Regional Planning Board
Las Vegas Valley Water District

Zone	D.U.	Sq. Ft. Avg. Lawn	% With Lawn	Total Sq. Ft. of Lawns	Cemetaries, Parks, Schools	Industrial Hotels Motels Hospitals	Sq. Ft. Total [illegible]	Total Acres
210	248	3000	80	595,200	0	0	595,200	13.66
211	821	1500	80	985,200	0	0	985,200	22.62
212	231	1500	80	277,200	21,000	0	298,200	6.85
213	534	1500	80	700,800	16,000	0	716,800	16.46
214	0	0	0	0	0	0	0	0
215	1	500	100	500	0	0	500	.01
216	200	2000	90	360,000	0	0	360,000	8.26
217	772	1500	90	1,389,600	0	0	1,389,600	31.90
218	0	0	0	0	0	0	0	0
301	796	1800	85	1,217,880	100,000	0	1,317,880	30.25
302	631	2000	80	1,009,600	80,000	0	1,089,600	25.01
303	751	2000	80	1,201,600	0	0	1,201,600	27.58
304	1814	1500	80	2,176,800	0	0	2,176,800	49.97
305	1363	1500	80	1,635,600	0	0	1,635,600	37.55
306	176	2500	90	396,000	0	0	396,000	9.09
307	1764	1500	90	2,381,400	225,000	0	2,606,400	59.83
308	880	1500	90	1,188,000	80,000	0	1,268,000	29.11
309	84	2000	80	134,400	400,000	0	534,400	12.27
310	0	0	0	0	0	0	0	0
311	0	0	0	0	0	0	0	0
312	0	0	0	0	0	0	0	0
313	0	0	0	0	0	0	0	0

June 1973 Dwelling Units
Clark County Regional Planning Board
Las Vegas Valley Water District

Zone	D.U.	Sq. Ft. Avg. Lawn	% With Lawn	Total Sq. Ft. of Lawns	Cemetaries, Parks, Schools	Industrial Hotels Motels Hospitals	Sq. Ft. Total Lawns	Total Acres
314	0	0	0	0	0	0	0	0
401	170	200	40	13,600	0	0	13,600	.31
402	440	800	50	176,000	0	0	176,000	4.04
403	350	2000	90	630,000	0	0	630,000	14.46
404	912	800	50	36,480	0	0	36,480	8.37
405	469	800	70	26,264	0	0	26,264	6.03
406	667	1500	80	800,400	20,000	0	820,400	18.83
407	829	1000	80	663,200	51,000	0	714,200	16.39
408	700	1500	90	945,000	720,000	0	1,665,000	38.22
409	655	800	70	366,800	128,000	0	494,800	11.35
410	427	1200	70	358,680	225,000	0	583,680	13.40
411	153	500	50	38,250	0	0	38,250	.87
412	624	500	80	249,600	0	15,000	264,600	6.07
501	246	1800	90	398,520	180,000	8,000	586,520	13.46
502	678	500	90	305,100	0	0	305,100	7.00
503	451	1500	90	608,850	60,000	0	668,850	15.35
504	384	150	90	51,840	0	67,000	118,840	2.73
505	127	2000	100	254,000	2,386,500	0	2,640,500	60.61
506	533	1500	85	568,650	445,000	0	1,013,650	23.27
507	1894	1800	90	3,068,280	99,500	3,000	3,170,780	72.79
508	384	500	80	153,600	20,000	0	173,600	3.98
509	256	1000	80	204,800	0	0	204,800	4.70

June 1973 Dwelling Units
Clark County Regional Planning Board
Las Vegas Valley Water District

Zone	D.U.	Sq. Ft. Avg. Lawn	% With Lawn	Total Sq. Ft. of Lawns	Cemetaries, Parks, School	Industrial Hotels Motels Hospitals	Sq. Ft. Total Lawns	Total Acres
510	142	1000	60	85,200	0	0	85,200	1.95
511	680	1500	80	816,000	0	5,000	821,000	18.84
512	472	1500	70	495,600	538,000	6,000	1,039,600	23.87
601	47	500	80	18,800	0	0	18,800	.43
602	0	0	0	0	150,000	0	150,000	3.44
603	0	0	0	0	0	0	0	0
604	0	0	0	0	50,000	0	50,000	1.14
605	0	0	0	0	0	0	0	0
606	0	0	0	0	0	0	0	0
607	0	0	0	0	15,000	0	15,000	.34
608	0	0	0	0	0	0	0	0
609	385	500	50	96,250	0	0	96,250	2.21
610	240	500	50	60,000	0	0	60,000	1.37
611	269	500	60	80,700	0	30,000	110,700	2.54
612	471	500	60	141,300	0	0	141,300	3.24
613	1374	700	70	673,260	80,000	0	753,260	17.29
614	686	700	80	384,160	0	7,000	391,160	8.98
615	958	2000	90	1,724,400	150,000	0	1,874,400	43.03
616	238	2000	90	428,400	0	0	428,400	9.83
617	284	500	90	127,800	0	4,000	131,800	3.03
618	780	2000	90	1,404,000	0	0	1,404,000	32.23
619	807	1500	90	1,089,450	0	0	1,089,450	25.01

June 1973 Dwelling Units
Clark County Regional Planning Board
Las Vegas Valley Water District

Zone	D.U.	Sq. Ft. Avg. Lawn	% With Lawn	Total Sq. Ft. of Lawns	Cemetaries, Parks, School	Industrial Hotels Motels Hospitals	Sq. Ft. Total Lawns	Total Acres
620	812	500	90	365,400	0	0	365,400	8.39
621	132	2000	90	237,600	0	0	237,600	5.45
622	2083	400	90	749,880	490,000	0	1,239,880	28.46
623	215	700	90	135,450	0	0	135,450	3.11
624	56	100	50	2,800	0	0	2,800	.06
625	1960	300	50	294,000	49,000	0	343,000	7.87
626	508	300	50	76,200	0	0	76,200	1.74
627	865	1500	80	1,038,000	0	0	1,038,000	23.83
628	903	1500	80	1,038,600	0	0	1,083,600	24.88
629	493	1500	80	591,600	200,000	0	791,600	18.17
630	574	2000	80	918,400	14,000	32,500	964,900	22.15
631	190	2000	60	228,000	60,000	10,000	298,000	6.84
632	466	500	95	221,350	0	0	221,350	5.08
633	479	1800	90	775,980	0	80,000	855,980	19.65
634	375	1800	90	607,500	0	0	607,500	13.94
635	162	1800	80	233,280	0	0	233,280	5.36
636	562	1500	80	674,400	0	10,000	684,400	15.71
637	450	1800	90	729,000	60,000	0	789,000	18.11
638	109	1800	90	176,580	320,000	25,000	521,580	11.97
639	1291	200	90	232,380	50,000	20,000	302,380	6.94
640	0	0	0	0	0	0	0	0
641	0	0	0	0	0	0	0	0

June 1973 Dwelling Units
Clark County Regional Planning Board
Las Vegas Valley Water District

Zone	D.U.	Sq. Ft. Avg. Lawn	% With Lawn	Total Sq. Ft. of Lawns	Cemetaries, Parks, School	Industrial Hotels Motels Hospitals	Sq. Ft. Total Lawns	Total Acres
642	336	2000	90	604,800	0	0	604,800	13.88
701	262	100	90	23,580	0	250,000	273,580	6.28
702	15	500	90	6,750	0	250,000	256,750	5.89
703	2081	500	100	1,040,500	0	0	1,040,500	23.89
704	2372	1500	80	2,846,400	794,000	0	3,640,400	83.57
705	1179	2000	90	2,122,200	0	0	2,122,200	48.72
706	1351	1000	85	1,148,350	192,000	0	1,340,350	30.77
707	466	500	95	221,350	0	40,000	261,350	5.99
708	2711	500	95	1,287,725	0	100,000	1,387,725	31.86
709	5474	500	95	2,600,150	0	0	2,600,150	59.69
710	786	2000	90	1,414,800	0	0	1,414,800	32.48
711	226	2000	80	361,600	37,500	0	399,100	9.16
712	750	2000	80	1,200,000	0	0	1,200,000	27.55
713	0	0	0	0	0	0	0	0
714	114	100	90	10,260	0	0	10,260	.24
715	1948	250	95	462,650	0	0	462,650	10.62
716	591	500	95	280,725	420,600	0	701,325	16.10
717	907	2000	90	1,632,600	85,000	0	1,717,600	39.43
718	235	2000	80	376,000	0	0	844,000	8.63
719	2631	1500	80	3,157,200	190,000	0	3,347,200	76.84
720	79	200	30	4,740	0	300,000	305,400	.10
721	234	100	60	14,040	0	280,000	294,040	6.75

June 1973 Dwelling Units
Clark County Regional Planning Board
Las Vegas Valley Water District

Zone	D.U.	Sq. Ft. Avg. Lawn	% With Lawn	Total Sq. Ft. of Lawns	Cemetaries, Parks, School	Industrial Hotels Motels Hospitals	Sq. Ft. Total Lawns	Total Acres
722	0	0	0	0	0	0	0	0
723	1309	1000	60	785,400	0	0	785,400	18.03
724	36	2000	90	64,800	0	0	64,800	1.49
725	651	2000	80	1,041,600	58,600	0	1,100,200	25.26
726	223	2000	80	356,800	0	0	356,800	8.19
727	490	2000	80	784,000	0	0	784,000	17.99
728	101	2000	80	161,600	0	0	161,600	3.71
729	54	1500	80	64,800	150,000	35,000	249,800	5.73
730	95	3000	90	256,500	0	0	256,500	5.89
731	1725	1500	60	1,552,500	0		1,552,500	35.64
732	0	0	0	0	0	0	0	0
733	595	1000	80	476,000	0	0	476,000	10.93
734	1369	1000	80	1,095,200	0	0	1,095,200	25.14
735	215	2000	90	387,000	0	0	387,000	8.88
736	489	800	70	312,960	0	0	312,960	7.18
737	524	200	70	73,360	0	0	73,360	1.68
801	267	1000	80	213,600	0	0	213,600	4.90
802	24	500	80	9,600	0	0	9,600	.22
803	0	0	0	0	0	0	0	0
804	244	1000	50	122,000	0	0	122,000	2.80
805	0	0	0	0	0	0	0	0
806	0	0	0	0	0	0	0	0
TOTAL	86,647	Square Feet		85,723,174	11,167,880	1,699,300	98,590,354	
		Acres		1,968	256	39		2,263

June 1973 Dwelling Units
Clark County Regional Planning Board
Nellis Air Force Base

Zone	D.U.	Sq. Ft. Avg. Lawn	% With Lawn	Total Sq. Ft. of Lawns	Cemeteries, Parks, School	Industrial Hotels Motels Hospitals	Sq. Ft. Total Lawns	Total Acres
532	747	1200	95	851,580	0	0	851,580	19.55
534	492	300	100	246,000	0	0	246,000	5.64
TOTAL	1,239	Square Feet		1,097,712	0	0	1,097,580	
		Acres						25.19

Lawn Acreage Distribution by Water Districts - 1973

	Dwelling Units	Lawns	Cemeteries Parks Schools	Industrial Hotels Motels Hospitals
Las Vegas Valley Water District	86,647	1968 acres	256 acres	39 acres
North Las Vegas	12,783	223 acres	31 acres	2 acres
Henderson	4,220	79 acres	1 acre	0 acres
Nellis AFB	1,239	25 acres	0 acres	0 acres
Private Wells	4,000	136 acres	0 acres	0 acres
TOTAL	108,889	2431 acres	288 acres	41 acres

June 1973 Dwelling Units
Clark County Regional Planning Board
Henderson Water District

Zone	D.U.	Sq. Ft. Avg. Lawn	% With Lawn	Total Sq. Ft. of Lawns	Cemetaries Parks, School	Industrial Hotels Motels Hospitals	Sq. Ft. Total Lawns	Total Acres
901	128	1000	80	102,400	0	0	102,400	2.35
902	450	1000	80	360,000	0	0	360,000	8.26
903	242	1000	80	193,600	0	0	193,600	4.44
904	184	1000	80	147,200	0	0	147,200	3.38
905	72	1000	80	57,600	0	0	57,600	1.32
906	58	1000	80	46,400	0	0	46,400	1.07
907	161	1500	80	193,200	0	0	193,200	4.44
908	210	1000	80	168,000	0	0	168,000	3.86
909	228	1000	80	182,400	0	0	182,400	4.19
910	78	1000	80	62,400	0	0	62,400	1.43
911	64	1000	80	51,200	0	0	51,200	1.18
912	124	1000	80	99,200	0	0	99,200	2.28
913	840	1000	80	672,000	20,000	0	692,000	15.89
914	392	1000	80	313,600	0	0	313,600	7.20
915	270	1000	80	216,000	0	0	216,000	4.96
916	120	1000	80	96,000	0	0	96,000	2.20
917	0	0	0	0	5,000	0	5,000	.11
918	0	0	0	0	0	0	0	0
919	599	1000	80	479,200	0	0	479,200	11.00
TOTAL	4,220	Square Feet		3,440,400	25,000	0	3,465,613	
		Acres						79

June 1973 Dwelling Units
Clark County Regional Planning Board
North Las Vegas Water District

Zone	D.U.	Sq. Ft. Avg. Lawn	% With Lawn	Total Sq. Ft. of Lawns	Cemetaries, Parks, School	Industrial Hotels Motels Hospitals	Sq. Ft. Total Lawns	Total Acres
413	0	0	0	0	0	12,000	12,000	.27
414	718	1000	80	574,400	0	0	574,400	13.19
415	781	1000	80	624,800	0	0	624,800	14.34
416	0	0	0	0	0	0	0	0
417	0	0	0	0	0	0	0	0
418	11	500	50	2,750	0	0	2,750	.06
419	0	0	0	0	0	57,000	57,000	1.30
421	0	0	0	0	0	0	0	0
512	0	0	0	0	0	0	0	0
513	1428	1500	80	1,713,600	55,000	0	1,768,600	40.60
514	77	1000	50	38,500	0	0	38,500	.88
515	1460	1200	80	1,401,600	419,500	0	1,821,100	41.81
516	2	500	100	1,000	0	3,200	4,200	.10
517	1503	1000	70	1,052,100	592,000	0	1,644,100	37.74
518	1135	800	80	726,400	0	0	726,400	16.68
519	1898	1200	80	1,822,080	130,000	0	1,952,080	44.81
520	407	1200	80	390,720	30,000	0	420,720	9.66
521	218	1500	80	261,600	60,000	0	321,600	7.38
527	456	500	80	182,400	0	0	182,400	4.19
528	729	100	90	65,610	0	0	65,610	1.51
529	156	500	80	62,400	0	0	62,400	1.43
530	635	800	60	304,800	80,000	0	384,800	8.83
531	1169	600	70	490,980	0	0	490,980	11.27
TOTAL		Square Feet		9,713,880	1,366,500	72,800	11,153,180	
		Acres		223	31	2		256

Appendix 2. Septic Tanks by Zone for Years
1972, 1970, 1965, 1958, 1950, 1943
(zones not listed did not have septics from 1943-1972)

SEPTIC TANKS

1975 LV Trans Study Zone #	1943		1950		1958		1965		1970		1972	
	D.U.*	Pop.	D.U.	Pop.	D.U.	Pop.	D.U.	Pop.	D.U.	Pop.	D.U.	Pop.
105	0	0	7	17	7	21	28	103	40	120	57	171
106	0	0	0	0	0	0	25	172	38	120	93	279
107	7	21	0	0	0	0	10	33	11	33	14	42
108	0	0	0	0	0	0	0	0	1	2	2	6
109	0	0	0	0	0	0	3	4	3	8	4	12
110	0	0	0	0	0	0	7	11	4	11	19	57
111	10	30	10	24	10	30	11	31	24	56	33	99
112	0	0	0	0	0	0	3	7	6	15	6	15
203	46	138	115	276	181	543	94	310	94	310	94	310
204	0	0	75	180	6	18	43	172	43	172	43	172
207	0	0	0	0	0	0	0	0	0	0	1	3
210	9	27	13	31	0	0	0	0	0	0	0	0
211	8	24	79	190	15	45	55	169	61	183	63	189
213	0	0	0	0	0	0	50	215	56	168	56	168
214	0	0	0	0	0	0	3	7	6	20	6	20
215	0	0	17	41	0	0	0	0	0	0	0	0
218	0	0	0	0	0	0	11	36	12	35	12	35
301	8	24	4	10	0	0	0	0	0	0	0	0
302	6	18	5	12	0	0	0	0	0	0	0	0
303	0	0	63	151	200	600	197	685	202	606	205	615
305	0	0	5	12	5	15	0	0	0	0	0	0
306	4	12	33	79	59	177	288	1094	326	978	341	1023
307	0	0	0	0	21	63	62	244	68	204	73	219
309	0	0	1	3	1	3	33	94	46	134	64	192
311	0	0	0	0	0	0	4	14	4	14	4	14
312	0	0	0	0	0	0	6	20	5	16	6	18
313	0	0	0	0	0	0	133	494	132	474	135	405

Septic Tanks

1975 LV Trans Study Zone #	1943 D.U.*	1943 Pop.	1950 D.U.	1950 Pop.	1958 D.U.	1958 Pop.	1965 D.U.	1965 Pop.	1970 D.U.	1970 Pop.	1972 D.U.	1972 Pop.
401	11	33	117	280	0	0	0	0	0	0	0	0
402	12	36	10	24	0	0	0	0	0	0	0	0
403	26	78	145	348	68	204	68	204	68	204	58	204
405	0	0	13	31	0	0	0	0	0	0	0	0
406	23	69	26	62	53	159	0	0	0	0	0	0
407	0	0	18	43	59	177	65	204	65	204	68	204
408	2	6	3	7	0	0	0	0	0	0	0	0
409	11	33	67	161	0	0	0	0	0	0	0	0
411	8	24	40	96	297	891	343	12	344	1078	344	1078
412	0	0	7	17	9	27	14	80	14	0	17	58
413	2	6	1	3	3	9	21	63	0	0	0	0
414	0	0	3	7	4	12	7	31	7	31	7	31
415	2	6	16	38	35	105	5	21	5	21	5	21
416	0	0	0	0	0	0	0	0	3	11	3	11
417	0	0	0	0	0	0	37	77	39	127	46	161
418	0	0	1	2	2	6	8	29	7	23	14	51
419	0	0	2	5	4	12	78	196	76	370	92	447
420	0	0	1	2	26	78	89	336	109	338	150	465
421	0	0	3	7	6	18	12	42	14	40	31	88
422	0	0	2	5	14	42	26	101	36	133	38	140
501	0	0	101	242	0	0	0	0	0	0	0	0
504	5	15	237	569	0	0	0	0	0	0	0	0
505	0	0	6	14	0	0	0	0	0	0	0	0
506	0	0	4	10	0	0	0	0	0	0	0	0
507	0	0	13	31	11	33	0	0	0	0	0	0
508	0	0	4	10	29	87	8	32	11	33	20	60
509	97	291	136	326	338	1014	0	0	0	0	0	0

Septic Tanks

1975 LV Trans Study Zone #	1943 D.U.*	1943 Pop.	1950 D.U.	1950 Pop.	1958 D.U.	1958 Pop.	1965 D.U.	1965 Pop.	1970 D.U.	1970 Pop.	1972 D.U.	1972 Pop.
510	36	108	39	94	212	636	0	0	0	0	0	0
511	83	249	320	768	327	981	0	0	0	0	0	0
512	0	0	14	34	0	0	0	0	0	0	0	0
513	0	0	15	36	0	0	0	0	0	0	0	0
514	0	0	37	89	16	48	0	0	0	0	0	0
515	0	0	83	199	285	855	0	0	0	0	0	0
516	0	0	13	31	37	111	0	0	0	0	0	0
517	0	0	129	310	330	990	0	0	0	0	0	0
518	3	9	6	14	81	243	0	0	0	0	0	0
519	8	24	19	46	166	498	0	0	0	0	0	0
520	0	0	2	5	4	12	0	0	0	0	0	0
521	0	0	1	2	3	9	6	19	0	0	0	0
523	0	0	9	22	104	312	24	72	24	72	28	84
524	0	0	29	70	92	276	0	0	0	0	5	15
525	2	6	2	5	28	84	0	0	0	0	0	0
526	0	0	1	2	25	75	0	0	0	0	0	0
527	0	0	17	41	57	171	0	0	0	0	0	0
528	0	0	1	2	21	63	0	0	0	0	0	0
529	0	0	2	5	23	69	0	0	0	0	0	0
530	0	0	19	46	18	54	2	8	4	12	4	12
531	0	0	3	8	13	39	16	48	16	48	18	54
622	0	0	149	357	23	69	0	0	0	0	1	3
623	4	12	9	22	17	51	0	0	0	0	0	0
632	0	0	1	3	0	0	0	0	0	0	0	0
635	0	0	4	10	4	12	0	0	0	0	0	0
636	12	36	30	74	0	0	0	0	0	0	0	0
637	0	0	2	5	0	0	0	0	0	0	0	0

Septic Tanks

1975 LV Trans Study Zone #

	1943		1950		1958		1965		1970		1972	
	D.U.*	Pop.	D.U.	Pop.	D.U.	Pop.	D.U.	Pop.	D.U.	Pop.	D.U.	Pop.
639	27	81	113	271	0	0	0	0	0	0	0	0
640	0	0	0	0	0	0	23	66	59	165	82	229
641	3	9	0	0	0	0	42	130	47	113	63	151
642	0	0	0	0	0	0	2	5	4	10	6	15
704	7	21	2	5	6	18	0	0	0	0	0	0
705	0	0	8	20	3	9	0	0	0	0	0	0
707	10	30	0	0	0	0	0	0	0	0	0	0
708	11	33	6	15	15	45	0	0	0	0	0	0
709	0	0	52	125	55	165	55	165	55	165	55	165
710	0	0	0	0	4	12	0	0	0	0	0	0
711	0	0	4	10	28	84	0	0	0	0	0	0
712	0	0	0	0	13	39	0	0	0	0	0	0
713	0	0	0	0	2	6	0	0	2	8	10	30
714	0	0	1	3	1	3	0	0	0	0	0	0
715	1	3	5	13	8	24	0	0	0	0	0	0
716	1	3	1	2	10	30	0	0	0	0	0	0
717	2	6	9	22	26	78	0	0	0	0	0	0
718	0	0	5	13	9	27	14	42	22	66	30	90
719	0	0	1	3	5	15	7	21	11	33	14	42
720	0	0	0	0	0	0	7	16	8	24	11	33
721	1	3	31	74	57	171	0	0	0	0	0	0
722	1	3	44	106	49	147	51	153	60	121	65	195
723	9	27	20	50	21	63	0	0	0	0	0	0
724	2	6	6	15	46	138	0	0	0	0	0	0
725	4	12	10	25	44	136	18	75	0	0	0	0
726	0	0	1	3	9	27	0	0	0	0	0	0
727	0	0	6	15	30	90	75	237	82	246	85	255

Septic Tanks

1975 LV Trans Study Zone #	1943 D.U.*	1943 Pop.	1950 D.U.	1950 Pop.	1958 D.U.	1958 Pop.	1965 D.U.	1965 Pop.	1970 D.U.	1970 Pop.	1972 D.U.	1972 Pop.
728	0	0	6	15	16	48	0	0	0	0	0	0
729	0	0	3	8	6	24	0	0	0	0	0	0
730	0	0	12	30	27	81	77	267	93	279	101	303
731	0	0	42	101	17	51	48	204	51	153	55	165
732	0	0	1	2	1	3	2	6	3	10	29	87
733	6	18	16	40	0	0	0	0	0	0	0	0
734	0	0	0	0	0	0	0	0	125	375	127	381
735	0	0	0	0	0	0	0	0	0	0	1	3
736	0	0	0	0	0	0	0	0	0	0	1	3
737	0	0	0	0	0	0	3	8	4	12	5	15
804	0	0	27	65	49	147	138	544	368	1104	427	1281
805	0	0	0	0	0	0	48	166	58	154	66	198
806	0	0	1	3	1	3	9	37	20	62	23	69
Area north of Centennial Parkway and west of Piedomont		0	0	0	0	0	0		183	549	0	0
TOTAL	530	1590	2791	6720	4078	11721	2514	8762	3096	9320	3731	11518

Appendix 3. Swimming Pools by Zones, 1971
(zones not listed did not have swimming pools in 1971)

SWIMMING POOLS IN LAS VEGAS VALLEY - OCTOBER 1971

LV Trans. Study Zone Number	Number of Pools in Zone	LV Trans. Study Zone Number	Number of Pools in Zone
102	34	407	13
103	24	412	2
104	68	420	4
105	76	501	1
106	3	502	6
107	2	503	30
203	65	504	1
204	192	506	17
205	60	507	68
206	82	508	8
207	77	512	4
208	9	513	55
210	76	514	2
211	232	515	14
212	23	517	13
213	53	518	3
216	63	519	27
217	94	520	2
301	103	521	1
302	70	523	1
303	25	524	3
304	53	525	2
305	62	526	2
306	48	527	4
307	74	530	4
308	36	604	1
403	6	605	1
406	3	606	1

Swimming Pools in Las Vegas Valley

LV Trans. Study Zone Number	Number of Pools in Zone	LV Trans. Study Zone Number	Number of Pools in Zone
607	2	701	8
613	2	702	12
614	8	703	59
615	2	704	176
616	4	705	152
617	1	706	35
618	2	707	20
619	19	708	84
620	23	709	53
621	7	710	257
622	15	711	66
623	6	712	25
625	31	714	10
626	9	715	35
627	15	716	3
628	63	717	63
629	33	718	72
630	33	719	97
631	19	720	2
632	15	721	20
633	26	722	9
634	12	723	79
635	12	724	2
636	13	725	8
637	13	726	11
638	2	727	41
639	13	728	7
642	11	729	2

Swimming Pools in Las Vegas Valley

LV Trans. Study Zone Number	Number of Pools in Zone	LV Trans. Study Zone Number	Number of Pools in Zone
730	31		
731	19		
733	7		
734	15		
735	23		
736	14		
801	8		
804	9		
805	1		
901	1		
910	1		
912	3		
914	6		
915	4		
916	4		
919	2		
TOTAL	4,004		